Hermes Bound

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Hermes Bound

The Policy and Technology of Telecommunications

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Preface

This book began as a study of the impact of telecommunications on society. As the study progressed it became apparent that in addition to the widely discussed impacts of telecommunications on social behavior, business operations, and cultural mores, society has an equally profound impact on the development and application of the technology of telecommunications. This latter phenomenon is little appreciated by those not directly involved with policy decisions in the telecommunications field, and its significance is not always readily seen when viewed as a series of isolated occurrences. However, when the overall picture of the regulatory, legislative, and judicial control of telecommunications development is examined clearly, substantive and far-reaching decisions are being made in the political arena that determine in large measure the nature, kind, and timing of many telecommunications related developments.

Chapter 1 discusses the nature and scope of the telecommunications revolution that is occurring in the United States and the whole world. It also briefly considers societal impacts and the societal controls of telecommunications development.

In order to appreciate the magnitude and significance of the controls society exercises on telecommunications development, it is necessary to understand the technological, political, and

economic factors underlying this industry and its developmental environment. Chapters 2 and 3 introduce the technology of telecommunications, the political arena and its various actors, and the economic principles that govern operation of the telecommunications industry.

Chapters 4 and 5 discuss in detail examples of the interplay of the technological, political, and economic factors affecting the introduction or suppression of new services and technological developments in radio and television broadcasting and in telephony. Each chapter provides extensive references to original sources and to additional related material. The Appendix includes excerpts from selected legal documents that have played important roles in telecommunications development. These excerpts were included to give those readers not having easy access to such documents an opportunity to study the original materials.

Chapter 6 outlines the general parameters of technological impact on society. While this book is focused on the impact of society on technological development, it is worthwhile to provide some perspective on the other side of the technological-society relationship. Chapter 6 attempts to make a set of general statements about the aspects of society which might reflect the kinds of changes that telecommunications technology will bring in years to come.

Chapter 7 focuses on some possible means of changing or determining the development of technology in this field in the future. Several basic questions need to be addressed by policy makers and members of the public, if future development is going to progress in an understood and systematic fashion. This last chapter examines these questions. Possibly, the answers to these problems will not emerge from the discussion in Chapter 7, but government officials and leaders in the telecommunications industry might consider

suggestions made there as they make future decisions.

Hermes Bound is not intended primarily as a textbook although it might be so used in an interdisciplinary course or seminar in public policy and technological development. Rather, the book is intended to be a detailed overview of the forces controlling technological development in telecommunications. As such it should be useful as a reference and source book for students in political science, economics, public policy, engineering, communications, and government. No expertise is assumed on the part of the reader in any of the areas covered. For those who are familiar with part or all of the background material contained in Chapters 2 and 3, it would be appropriate to skip immediately to the later chapters which are essentially self-contained.

Acknowledgments

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Chapter 1

Telecommunications Technology and Society: An Overview

The relationships between technology and society are complex and multifaceted. One can find literally thousands of empirical studies of these relationships.(1,2) Much of the emphasis in such studies is on the impact of technological development on society. However, an equally important, but much less studied area, is the manner and degree of control of technological development by society itself. The technology of telecommunications is an example in which the impact of the technology on society has been profound and is clearly evident throughout the world. The ways in which society influences development and application of this technology are much more subtle and diffuse but nevertheless are also profoundly important. It is toward a more complete understanding of the relationship between society and telecommunications technology that this book is aimed. It will examine the technology itself along with various political, economic, and social factors that have influenced its development and utilization.

The early chapters of this book examine the kinds of influences which economics, politics, and technical constraints have on the development of telecommunications. The later chapters explore how specific decisions affecting telecommunications development were arrived at in the past and how these decisions altered the development proc-

ess. The primary focus of this portion of the book is on decisions made by public officials, by people in the telecommunications industry, and by the consuming public which have significantly shaped the development of telecommunications in this country.

Whether or not the forces controlling telecommunications development at any moment are in proper balance to promote the common good is difficult to assess. By looking in detail at how these forces have led us to our present development, hopefully, some guidance can be provided for improving upon or at least preserving the successful evolution that has occurred in this field over the past century.

Two basic categories of telecommunications services and their associated technologies encompass most of the material discussed in the following chapters. The first is telephony and its subsidiary developments. The second is broadcasting of programs aimed at the commercial attraction of mass audiences. In order to acquaint the reader with some of the background underlying these areas a brief introduction to each will be presented before proceeding with the more detailed considerations of how they came to their present development and where they are going.

Telephone Communications

Technologically, the invention of the telephone was a logical extension of the state of the art as it existed in the second half of the nineteenth century. If Alexander Graham Bell had not patented the telephone in February 1876, someone else would have within a short time. In fact, there was considerable litigation over the true inventor of the telephone before the Supreme Court, in a dividend vote, upheld Bell's patent. (3) Over the years improvement in telephone service has con-

tinued as a result of evolution of the technological foundations upon which telephony is based. From time-to-time major breakthroughs have greatly enhanced the performance attainable. Important developments in telephony are listed in Table 1-1 which also shows the nature of the impact that the development produced. The abbreviated listing in Table 1-1 omits some highly significant developments. However, it does illustrate some important aspects of the technological development process.

Mostly, the evolution of telephone technology has been regular and continuous. At times, however, major technological breakthroughs have led to quantum jumps in service, performance, or economy. Table 1-1 lists several such developments that produced major changes in the rate of development and implementation of telephony. The first was the development of the vacuum triode. Since its earliest days the telephone was plagued by the problem of loss of signal intensity as the distance between the transmitter and receiver increased. This led to serious doubts about the possibility of long distance communication over telephone circuits. Invention of the vacuum triode solved this problem by making amplification of weak signals possible. Thus it was possible to place repeaters along a transmission line to amplify the signals and thereby compensate for the natural attenuation of the system. The vacuum triode ushered in a whole era in telecommunications that lasted for half a century. Its effects extended far beyond telephony into radio, television, and computers and led to the development of electronics as a major industry of the mid-twentieth century.

Interestingly, the second revolutionary development in Table 1-1 is the transistor, which was a precursor of the technology that is replacing vacuum tubes in telecommunications and a variety of other fields. While remarkably effective, the

Table 1-1 Key Developments in Telephony

Date	Development	Impact
1876	Telephone patent (Bell)	Basic concept
1877	Carbon transmitter (Edison)	Great increase in signal level
1878	Telephone exchange	Interconnection of telephones
1889	Step-by-step switching (Strowger)	Automatic telephone switching
1899	Loading coils (Pupin, Campbell)	Made long distance possible
1914*	Vacuum triode (DeForrest, Langmuir)	Amplification of signals
1915	Electric wave filters (Campbell)	Allowed many signals on same wires
1918	Carrier telephony	Practical use of one pair of wires for many signals
1919	Crossbar switch (Palmgren, Betulander)	Improved automatic switching
1921	Submarine cable	Showed feasibility of undersea cable
1936	Coaxial cable transmission	Increased transmission capacity and lower cost
1947	Microwave relay	Reduced cost and increased transmission capacity
1948*	Transistor (Brattain, Bardeen, Shockley)	Miniaturization, reliability and cost reduction
1948	Information theory (Shannon)	Gave precise bounds on attainable performance
1951	Customer direct long distance dialing	Improved service
1956	Transatlantic cable	Reliable overseas telephony
1960	Integrated circuits	Extreme miniaturization and reliability
1965	Satellites	Reduced cost and improved service

*Events viewed as technological breakthroughs.

vacuum tube suffered from three serious drawbacks: its filament or heater generated much unwanted heat energy that had to be removed when many tubes were close together; the failure rate was much higher than would be desired; and the cost was relatively high. All of these drawbacks have been essentially eliminated by the transistor and the vast array of components that have evolved from the solid state technology on which the transistor is based.

Although the transistor was invented in 1947, not until the 1960's was the real impact of this technology fully felt. Simultaneous fabrication and mass production of many components into an "integrated circuit" led to the technological and economic feasibility of such things as communications satellites and electronic switching systems. Further technological development led to large-scale integrated circuits (LSI) that combine many complex subsystems onto small "chips" of silicon or other semiconductor materials. This process led to rapid development of high performance digital computers at remarkably low cost. This technology is also ushering in a potential revolution in telecommunication services that probably will continue for decades. The manner in which this almost incredible signal processing and control technology is brought to fruition will profoundly influence world social, political, and economic structures.

The development of technology and its incorporation into telecommunications is not a free and independent operation. In fact, many forces are at play, which strongly affect technological development and evolution. In the early days of telephony (1873-93) when it held a patent monopoly, the Bell System vigorously opposed any type of government intervention or regulation.(4) However, when the patent monopoly ended it became apparent that the only way to achieve stability

and rationality in the telephone industry was through some type of government regulation. In 1910 the United States Congress passed legislation which conferred regulatory authority over interstate telephone companies on the Interstate Commerce Commission (ICC).(4) The ICC retained this jurisdiction until 1934 when regulatory responsibility was transferred to the newly-formed Federal Communications Commission (FCC). The telephone industry now operates as a regulated monopoly in which rates and often services are controlled by state and federal agencies.

For most of the time since government regulation began, responsible agencies have protected the telephone monopoly. In recent years, however, there have been some departures from this policy.(5) Particularly in the 1968 *Carterfone* decision, the FCC ruled that private companies would be allowed to connect "foreign attachments" to the telephone system provided that they complied with appropriate precautions specified by AT&T, aimed at protecting the system from possible damage.(6) The telephone company vigorously opposed this decision but later it acquiesced. Now, such attachments as automatic answering devices, burglar alarms, and private exchanges are routinely available.

About the same time as the *Carterfone* decision, the FCC granted Microwave Communications Incorporated (MCI), a specialized carrier, permission to operate a microwave data transmission link from St. Louis to Chicago.(7) This directly infringed on an area previously considered part of the telephone monopoly. Again, AT&T vigorously opposed the decision, but it also took aggressive action on the technological front and developed a data transmission system that was more than financially competitive with the MCI system.

Telephone system development in the rest of the world has been largely through government

owned and operated systems and thus does not closely parallel that of the United States. Most systems are technically compatible and today a telephone subscriber in the United States can reach 90 percent of all the telephones in the world. Figure 1-1 shows the growth of telephone installations in the United States and in the world. The trend is upward, and telephone usage will likely continue to expand for many years. However, the number of telephones do not tell the whole story. The new services that are technically feasible and may be introduced in coming years represent an impact at least as great as that of the increasing utilization of existing services.

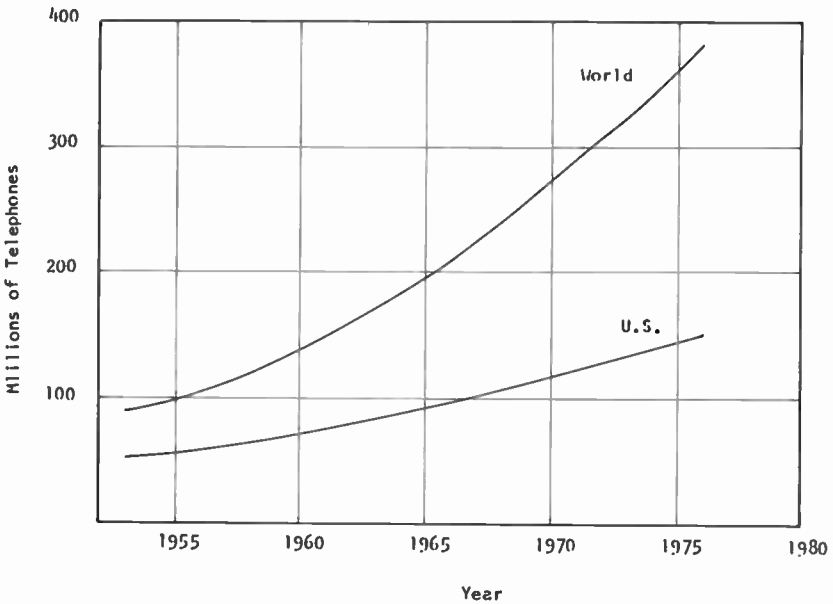

Figure 1-1 Growth of installed telephones
Source: *Statistical Abstract of U.S.*, 1976

The services and new developments already in sight include electronic switching systems (ESS) capable of automatically forwarding your calls to

other numbers, of recording messages, of automatic dialing frequently used numbers, and of many other conveniences. Domestic satellites will usher in an era of expanded data communication services throughout the United States. The use of optical fibers, thinner than a human hair, to carry broadband audio, video, and digital communication signals for both intercity transmission and for distribution to users may herald an era of greatly expanded telecommunication services in the home and office, revolutionizing society as we know it.

Radio and Television Broadcasting

Much like the invention of the telephone, the invention of radio was a product of its time. A number of investigators, both amateur and professional, experimented with the transmission and reception of electromagnetic waves for purposes of communicating signals from one location to another.(8) Guglielmo Marconi is generally credited with the explicit implementation that could properly be called the invention of radio. His apparatus was actually a wireless telegraph system and did not transmit speech or music directly. A sequence of technological developments led to the inauguration of commercial radio broadcasting in the 1920's. Some of these developments were the same as those involved in the development of telephony. Table 1-2 lists a number of important technological milestones in the development of radio and television broadcasting. Most of these developments were logical extensions of the state of the art and were absorbed into the broadcasting industry in a gradual, incremental fashion.

A notable exception to this evolution was the remarkable and unexpected development of frequency modulated radio waves (FM). This technological development represented a major breakthrough be-

cause of its virtual elimination of static and man-made interference that had plagued radio from its inception. Despite the superior performance of radios using this new type of modulation, this technology has developed much more slowly than

Table 1-2 Milestones in Radio and Television Technology

Date	Event	Impact
1895	Wireless telegraph (Marconi)	Demonstrated feasibility
1903	Transatlantic wireless (Marconi)	First transatlantic telecommunication
1906	Wireless transmission of speech and music (Fessenden)	Established feasibility of radio telephony and radio broadcasting
1906	Audion invented (DeForrest)	Electronic detector
1914*	Vacuum triode (DeForrest, Langmuir)	Electronic amplification
1917	Superhetrodyne receiver (Armstrong)	Great increase in sensitivity
1923	Iconoscope (Zworykin)	Television pickup tube
1932	Television (Zworykin)	Feasibility of TV demonstrated
1933*	Frequency modulation (Armstrong)	Permitted static-free radio
1939	TV broadcasting	Regularly scheduled public TV broadcasts
1949	CATV	Beginning of wired nation
1952	UHF TV	Expanded number of available channels
1953	Color TV	New dimension to TV
1961	Stereo FM	New dimension to radio broadcasting
1973	Quadraphonic FM	New dimension to sound reproduction

*Event considered as technological breakthrough.

was expected and has never displaced AM radio as the primary broadcasting medium. The reasons for this are complex and involve economic, political, and technological forces of various kinds. They will be discussed in detail in a later chapter. This suggests that the existence of a superior technology does not always guarantee that it will be accepted and used.

The public's acceptance of both radio and television broadcasting was rapid in the United States. There are almost two radio sets for every person, a ratio brought about by the very low cost of manufacturing radios utilizing solid state technology. And, with some 50 million television sets in the United States, penetration of this potential market is equally impressive. The low cost and high reliability of solid state electronic devices has strongly contributed to this development. Elsewhere in the world the acceptance of radio and television has been substantial. In 1974 South Africa was the largest country without its own television broadcasting system and it had plans to inaugurate television broadcasting in 1975 on a limited scale.(9) Interestingly, the Soviet Union has the next greatest number of television sets after the United States, although other countries exceed the Soviet Union on a per capita basis.

Societal Impact of Telecommunications Technology

The size of the telecommunications industry alone is enough to insure that it will have a major impact on many aspects of society. Even though the economic impact of telecommunications is enormous, this is probably not the source of its most significant influence on society. Rather, it is the increased availability of personal telecommunica-

tion via the telephone. The effects of the mass media on human behavior has been studied considerably but no definitive conclusions from these studies have been formed yet.(1,2) At the same time few persons doubt that a pervasive medium such as television, which accounts for about the same number of hours as formal schooling for the average teenager, will have substantial, long-term effects.(10) What these effects will be may not be known for a long time, if ever. Similar unanswerable questions can be asked about rock-and-roll and country music that dominate radio broadcasting.

Less obscure effects on social behavior are directly traceable to telecommunications services. Among these are the development of new eating habits such as the TV dinner, the decline and partial recovery of attendance at movie theaters, the characteristically protracted telephone conversations of teenagers, the explosion in popularity of professional sports, and the increased awareness by the general public of minority group opinions on a vast array of subjects from pollution to Indian rights.

As more potential services of advanced telecommunications technology are realized, the impacts on society will be more substantial and farther reaching. For instance, the conversion to a cashless society would have vast ramifications on the economic structure and on the ways of doing business and it might eliminate certain types of criminal activity by removing some incentives to commit crime.

Perhaps even more long-term effects would result from installation of computer-based information terminals in the home. Such terminals would provide a variety of services such as: shopping catalogues; selectable tutored educational services; selectable entertainment; specialized subscriber-oriented news services; automatic bank-

ing; and access to extensive information retrieval and processing facilities. Such terminals would have a two-way capability allowing interactive operations to be carried out via the terminal. The interactive operations may involve other people or they may involve computers or specialized automata. Two-way cable television or telephone could well be an inherent part of such a system. The influence that a telecommunications system with capabilities such as these could have on the cultural, economic, and political structure of a society are apparent.

Impact of Society on Technological Development

The existence of technological potential does not carry with it any assurance that such potential will be realized. Or, if it is to be realized, on what time scale this will occur. Some examples of this are the slow development of FM radio broadcasting, the even slower development of UHF TV broadcasting, the brief introduction and subsequent withdrawal of the Bell System's Picturephone® service, and the arrested development of CATV and pay TV.

What determines the viability of new technology? In each case different magnitudes and kinds of opposing political, economic, or social forces exist and ultimate decisions are determined by combinations of these forces. The effect of political decisions can be of major significance as illustrated by the following example. In the early 1960's government policy was to restrict communication satellite development to a single company (COMSAT) and this policy was followed during the entire development of the present international communication satellite system. However, in the late 1960's government policy had altered significantly and the development of domestic satellites

was opened to competition. New services and new technology will likely result from the decision to open up the field to new participants.

The political decision processes that affect telecommunications technology development revolve around the FCC, Congress, the Executive Branch, the courts, established industry, new entrants, and other groups such as consumers and private foundations. Because the economic stakes are high, there frequently is substantial lobbying by established industry groups when any portion of their vested interests is threatened by a new entrant. Such lobbying has generally been effective in that over the years political decisions have tended to protect the positions of the established industries. It appears very difficult to obtain political support for innovations if they threaten established telecommunications industries. This is particularly true if the industry is part of the mass media which are molders of public opinion and which are able to provide subtle positive and negative inducements to gain congressional support for their views. This matter is examined in more detail in a later chapter.

In addition to controlling or influencing telecommunications technology and services through legislative and regulatory action, there have been a variety of other attempts ranging from lobbying by citizen action groups to direct legal action by dissatisfied users of telecommunications services. In some cases they have been effective, in others they have not.

The important point is that there do exist avenues of control and influence by which society either directly or indirectly can, and, in fact, does control the development of new telecommunications technology and services. The role of the public or consumer in such precedures has been relatively insignificant over the years but this is one important factor that seems to be changing.

Many changes in regulatory philosophy and policy will be required before the consumer's voice is heard above the cacophony of other voices. Theoretically such changes are possible.

Economics also play a substantial role in determining the development and use of technology. The future market and regulated economics will contribute substantially to private and public decisions about the provision of services, the quality of those services, and the pace which innovation takes. Thus, it is important to examine the structure of economic considerations in order to appreciate the past developments and to foresee the likely future with any clarity.

This book explores the technical and political constraints which shape development in various telecommunications areas. As a first step it is necessary to provide the reader with a grasp of the basic technical factors which are affected by the economic and political decisions being made. That is the purpose of Chapter 2. Subsequent chapters will examine the other factors which influence technological developments, and will explore specific cases in which these factors have interacted to produce decisions which have controlled specific developments.

Chapter 2

Telecommunications Technology

There have been so many remarkable technological innovations in recent years that many people have come to accept them without any attempt to appreciate their underlying principles or to understand the basic limitations which govern the performance that is attainable. Certainly, obtaining a detailed knowledge of current telecommunication technology would require a great deal of study, far more than the nonspecialist would be willing to invest. Fortunately, however, a few basic concepts are readily understandable and provide an adequate foundation for appreciating many of the most important quantitative and qualitative aspects of telecommunications technology and the equipment utilized for implementing many available services.

This chapter intends to present in understandable form sufficient basic concepts underlying telecommunications theory to allow the nonexpert to understand the terminology of the engineer or scientist and to form his own judgment about the feasibility, desirability, and costs associated with present and future developments in this field. A glossary of terms at the end of the book provides a ready reference to the meaning of these terms when they are encountered throughout the book.(1,2)

Experimental Development Versus Theoretical Development

Much of the early development of telegraphy, telephony, and radio technology was based on an empirical or experimental approach. Such men as Morse, Bell, Edison, Marconi, de Forrest, and others of their era utilized great ingenuity, perserverance, and often intuitive insight in developing and perfecting their inventions. The theoretical basis of telecommunications virtually did not exist. Many of the underlying physical and mathematical laws governing the devices in use were known but had not been organized into a body of knowledge that was useful in explaining their operation or in extending their design to more advanced devices. During the 1920's and 1930's the theoretical basis of communications expanded continually. However, not until World War II was the full power of theoretical analysis brought to bear on development of the telecommunications technology. This came because of the urgent need to develop sophisticated radar, sonar, and communication equipment. To meet this need, special laboratories were formed and many highly capable physicists, mathematicians, and engineers were brought into these development programs. Except for the war, many of these individuals would never have been engaged in what has become known as communications engineering. Their impact was enormous both in their wartime accomplishments and in their long-term effects of placing communications engineering on a much more sound theoretical basis.

Shortly after World War II the analytical basis of communications science reached a pinnacle with publication by Claude Shannon of a paper entitled, "The Mathematical Theory of Communication."(3) In this paper Dr. Shannon presented a new, theoretical way of looking at the transmission of information.

He defined information in a general and useful manner and showed the limits of communication performance achievable in terms of the speed of transmission, the characteristics of the signal being transmitted, and the noise interfering with that transmission. Although the theory is abstract, many of the results are simple and give much insight that had previously been only intuitive or empirical in nature. Since then the theoretical basis of communication engineering has been continually expanding and today provides a means for accurately predicting the performance possible with various systems, for determining how well a system performs compared with the ultimate performance possible, and for comparing various alternate schemes before selecting one for a particular application.

Much experimental and empirical work is still conducted in communications engineering, particularly in the area of devices and components. This is because Shannon's analysis did not provide any practical means for obtaining ultimate performance, although it showed what that performance was. The goals of efficient communication are clearly stated but the paths to their achievement must be searched out individually. This is one aspect of communication engineering that has made it fascinating to so many people in the past two decades and that has contributed to the continual advances in technology past, present, and future.

Signals and Information

To begin a discussion of telecommunications technology, consider the electric telegraph and how it transmits information. Figure 2-1 shows an elementary telegraph system consisting of a battery, a telegraph key, a conductor, and an electromagnet. When the key is closed, the electric circuit is completed from the battery to the electro-

magnet and back through the ground which is also a good conductor of electricity. With the circuit closed, current flows through the electromagnet causing it to pull the lever down. When the key is released, the circuit is broken, stopping the current from flowing through the electromagnet, and, with no current, the electromagnet loses its pull, and the lever is released and pulled up by a spring.

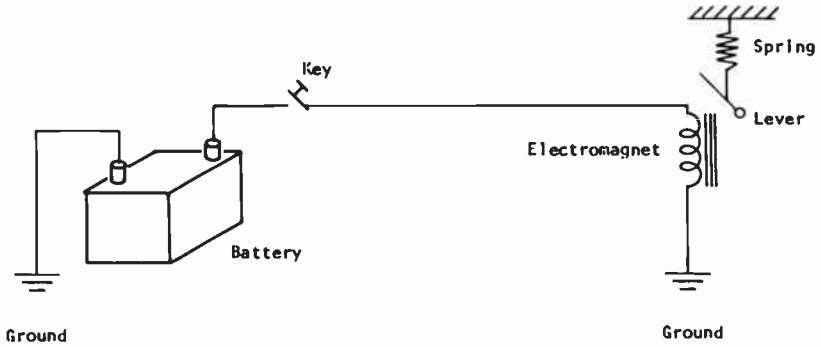

Figure 2-1 Elementary telegraph system

Signaling is accomplished by varying the length of time that the key is held down. For example, in the Morse Code used for radio telegraph transmissions the signals consist of a dot (key depressed briefly), a dash (key depressed three times as long as for a dot), and a space (key up). The complete Morse Code alphabet is shown in Table 2-1.

A signaling system such as the electric telegraph is called a binary system because it has essentially two states, open or closed, i.e., signal or no signal. Much study has been devoted to the communication problem as it relates to binary systems. The individual characters of a binary system are called binary digits and are usually referred to as *bits*. For example, a system that transmits ten characters each second is

said to have a transmission rate of 10 bits/sec. This concept of transmission rate is very important for, as will be seen shortly, transmission of all kinds of information can be measured in terms of these same units.

Table 2-1 Morse code

A • -	H • • • •	O - - -	V • • • -
B - • • •	I • •	P • - - •	W • - -
C - • - •	J • - - -	Q - - • -	X - • • -
D - • •	K - • -	R • - •	Y - • - -
E •	L • - • •	S • • •	Z - - • •
F • • - •	M - -	T -	
G - - •	N - •	U • • -	

More general coding schemes can be used with binary signaling systems. The most widely used methods operate at a constant rate of character transmission. If we consider the two states of the (binary) system as corresponding to the symbols 0 and 1, then a typical signaling sequence or message waveform might look as in Figure 2-2.

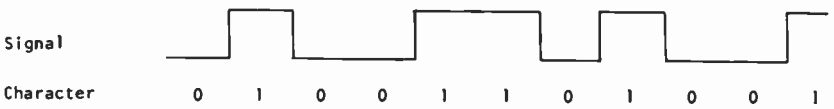

Figure 2-2 Binary signal and corresponding characters

Groups of the characters can be taken together to represent a specific symbol or word. For example, in the case of teletypewriters the binary characters are taken as groups of five and the various combinations and permutations of zeros and ones that can be made in five characters are assigned

specific symbols on the typewriter. Table 2-2 shows what typical five bit code words correspond to, for some commonly used teletypewriter applications. When a key is pressed, it produces the five characters shown and when the teletypewriter receives a particular five bit sequence it causes the corresponding key to be activated thereby printing that character on the paper.

Table 2-2 Teletype binary codes

Code Group	Lower Case	Upper Case for Three Different Codes		
	All Codes	Weather Code	AT&T Fraction	Int'l Alphabet No. 2
1000	A	↑	-	-
10011	B	●	5/8	?
01110	C	0	1/8	:
10010	D	↗	$	who are you?
10000	E	3	3	3
10110	F	→	1/4	not assigned
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

To get an idea of the rate of transmission required for a teletypewriter consider how many bits would be generated by a fast typist. Assume that typing is being done at an average of eighty five-letter words per minute. Since each letter requires five bits it follows that each five-letter word requires 25 bits plus five for the space between words. The transmission rate is therefore 80 x 30 = 2400 bits per minute or 2400 ÷ 60 = 40 bits per second. An automatic transmission system that employs a prepunched tape will operate at speeds up to 150 bits/sec. which is several times faster than a human operator is able to type.

Frequency and Bandwidth

Light, sound, radio waves, and telephone signals are all most conveniently described in terms of their frequency components. Frequency is the rate at which a periodic signal repeats itself. For example, consider sound waves. A violin string is vibrated by drawing the bow across it. A heavy, long string will vibrate slowly, while a light, short string will vibrate more rapidly. Changing the tension in the string also alters the frequency of vibration. It is the vibration of the strings, coupled to the air through the sounding board body of the violin that produces the sound heard by the ear. The sounds produced by a violin have frequencies from hundreds to thousands of cycles per second. The unit of frequency is the hertz (abbreviated Hz) and one cycle per second corresponds to one hertz. A thousand cycles per second is one kilohertz (abbreviated kHz) and a million cycles per second is one megahertz (MHz).

Human speech is generated by a complex interaction of the vocal chords and various cavities and structures of the head. All sound waves are pressure variations that are traveling through the air, or some other suitable medium, and when they strike an appropriate sensing device, such as an ear or a microphone, they set up vibrations that are detected. The ear is sensitive to sound vibrations in the range of 30 to 20,000 Hz, although certain ranges are much more important than others for conveying the information content of speech or music. Figure 2-3 shows a curve of the relative loudness to the human ear of sounds having the same amplitude but different frequencies. The maximum response is near a frequency of 1 kHz, which falls off rapidly on either side of this peak. Actually, the telephone system only carries speech components whose frequencies lie in the

range of 300 Hz to 3400 Hz. Thus, the bandwidth (B.W.) of the telephone signal is: 3400 - 300 = 3100 Hz or 3.1 kHz. In an actual system, a bandwidth of 4 kHz is normally allocated to speech transmission to allow guardspaces to be placed at the edges of the transmission band. This permits speech channels to be located adjacent to each other without interference.

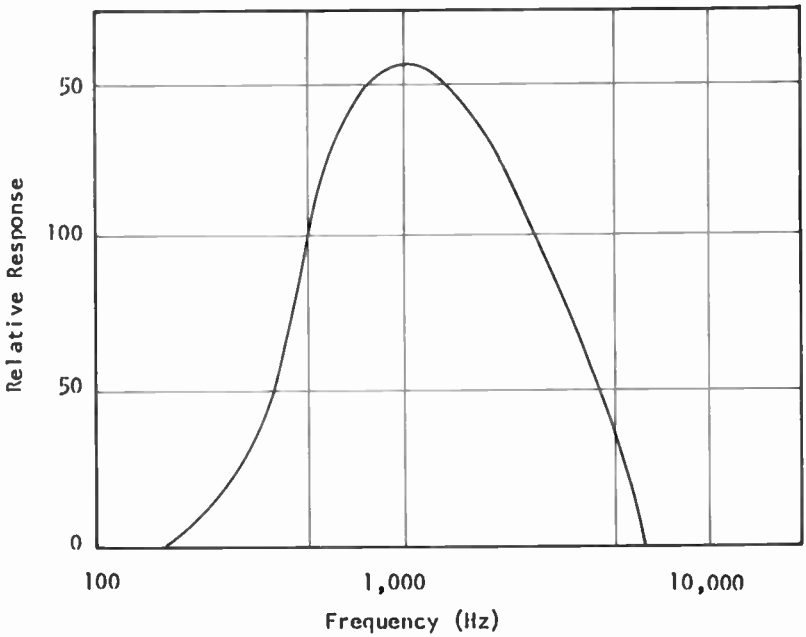

Figure 2-3 Frequency response of ear

Music sounds tinny when transmitted over a bandwidth no greater than that of the telephone. Fidelity improves when the bandwidth is increased to 5 kHz as in AM radio broadcasting or to 15 kHz reproduction over the entire bandwidth of the ear which is 20 to 20,000 Hz. This amounts to a bandwidth that is (20,000 - 20) ÷ 3100 = 6.4 times greater than that of the telephone. Since the

cost of transmitting signals is a direct function of their bandwidth, clearly telecommunication of music is significantly more expensive than that of speech. The problem is compounded further because good music reproduction requires lower noise channels than does typical speech communication. This causes a further increase in the cost of transmitting music.

Figure 2-4 shows the relation between the frequency scale and various familiar sounds.

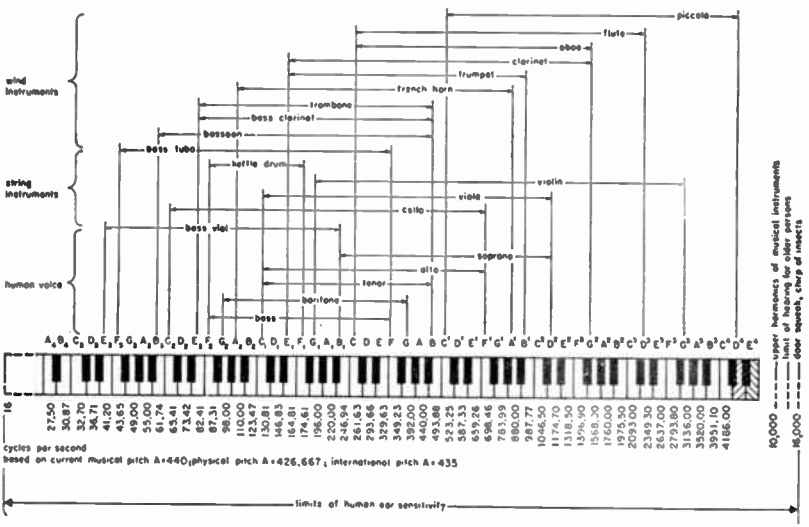

Figure 2-4 Spectra of sounds (From *Reference Data for Radio Engineers*, Howard W. Sams Co., Inc., 1975).

The key to successful transmission of signals corresponding to speech and music is to have sufficient bandwidth in the transmission channel. As the variations in amplitude of a signal become more rapid and complex, a greater transmission bandwidth is required for its faithful reproduction. For this reason, transmission of music requires a much greater bandwidth than does trans-

mission of telegraph signals. It will be seen shortly that the information bandwidths of 4 kHz for telephone transmission of speech and 5 or 15 kHz for music are vitally important in determining how many radio stations can be on the air at one time or how many telephone conversations can be handled by a communications satellite.

Telephone Transmission

Communication by sound waves is only feasible over short distances because of the rapid attenuation loss of the signal with distance, the disturbing effects on other people and the interference that would result when several signals are present simultaneously. In order to overcome this difficulty, the telephone converts the sound (pressure) signal into a varying electric current by means of a microphone or *telephone transmitter* as it is sometimes called. The resulting electrical signal is then sent over a wire to a telephone receiver. There the electrical signal actuates a metal diaphragm which regenerates sounds corresponding more or less to those that originally impinged on the telephone transmitter. Figure 2-5 shows this whole process. For the telephone to function properly, a circuit must be connected from each transmitter to each receiver. This is called a two-way voice circuit.

In the early days, telephone service was limited to short ranges because of the attenuation of the signal along the telephone wires. Long distance communication was measured in tens of miles. With the advent of the vacuum tube amplifier in 1914, the means for obtaining true long-distance communications was at hand. By installing amplifiers, or *repeaters* at appropriate intervals along a telephone line it was possible to maintain a high signal level and to achieve a

true long distance capability. Telephone service between New York and San Francisco was inaugurated in 1915. Transatlantic telephone service using submarine cable with undersea repeaters was inaugurated in 1956 between Newfoundland and Scotland.

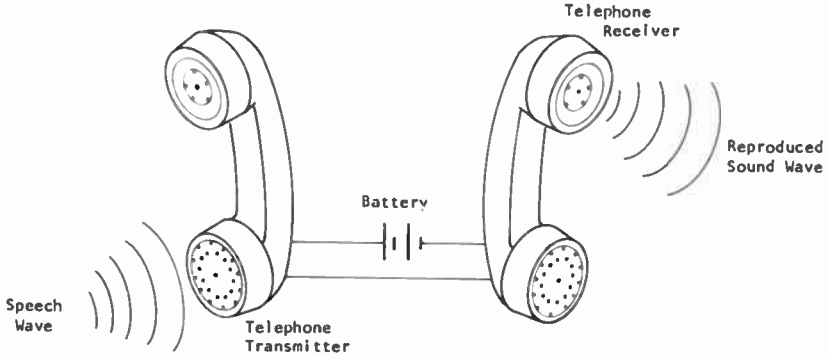

Figure 2-5 Elementary telephone system

Although providing a good communication link between two telephones is an important and difficult task, one that is equally important and actually more complex, is that of interconnecting all of the telephones so that each may call any other. This is the problem of telephone switching. It has evolved from rudimentary manual interconnection of a few telephones by an operator in a central office to computer-controlled switching systems that can now interconnect hundreds of millions of telephones, often in a matter of seconds.

Radio Waves

Simultaneously with the development of the telephone came the development of radio. It had been discovered in the late 1800's that there existed certain kinds of electric waves that could travel

through space without the need for conducting wires. These waves are called electromagnetic waves and are manifested as x-rays or light waves when their frequencies are very high and as radio waves when their frequencies are relatively low. The electromagnetic spectrum extends over a range so great as to be almost incomprehensible in any practical terms. Low frequency radio waves, say from 10 kHz to 30 MHz, are used for intermediate and long range radio communication. The AM radio broadcast band lies in the frequency range of 535 kHz to 1605 kHz, while international short wave broadcasts are at high frequencies. The particular frequencies employed for short wave broadcasting vary with the time of day, the time of year, and the status of the 11-year sun spot cycle since all of these factors strongly affect the layers of ionized gases surrounding the earth (the ionosphere) which reflect the signals back to earth permitting long distance communication. The frequencies used for international and other long range point-to-point communication are in the range of 3 to 30 MHz. Above about 30 MHz, electromagnetic waves are not reflected back to the earth by the ionosphere and so communications are limited to line-of-sight distances between antennas. It is in this band of frequencies, above 30 MHz, that television, FM radio, and police and emergency services lie. The upper frequency limit for this type of communication is about 1000 MHz or 1 GHz. Above this frequency radio waves fall into a category of radiation referred to as microwaves. These frequencies have found wide usage as part of the microwave relays that interconnect cities and provide for transmission of telephone calls, and radio and television network broadcasts. Microwave frequencies are also used for the up-and-down links in satellite communication. Figure 2-6 summarizes the usage of the electromagnetic spectrum.

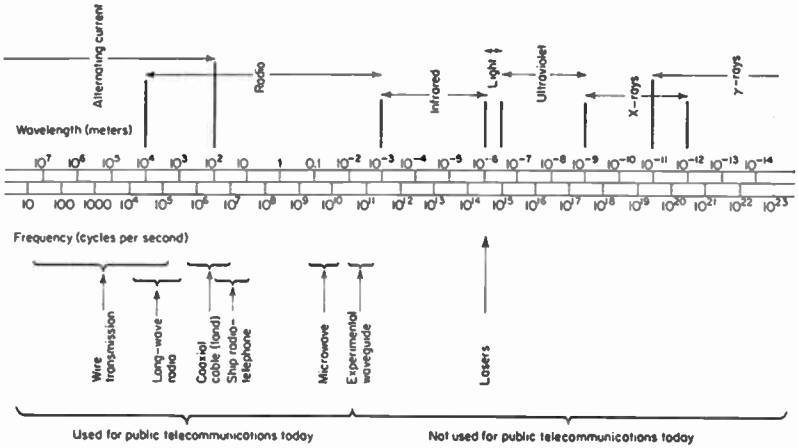

Figure 2-6 The electromagnetic spectrum (From J. Martin, *Telecommunications and the Computer*, Prentice Hall, Inc., 1969).

AM Broadcasting

Radio waves are used for communication by attaching the desired information to the radio wave at the transmitter and then removing the information at the receiver. Thus, the radio wave acts as a carrier. The process of attaching the information to the carrier is called modulation and the process of recovering the information is called demodulation or detection. A common type of modulation is that in which the amplitude (i.e., the magnitude) of the radio wave is caused to vary in the same manner as the sound pressure of the voice or music that is to be transmitted. When the sound is loud, the amplitude is large, and when the sound is soft, the amplitude is small. When the sound varies in pitch, the amplitude of the carrier varies in synchronism with the sound pressure oscillations. The radio wave is itself oscillating at a very high frequency--thousands to millions of times higher in frequency than the

sound wave oscillations. Figure 2-7 shows how an amplitude modulated wave would look if the message was a constant pitch sound.

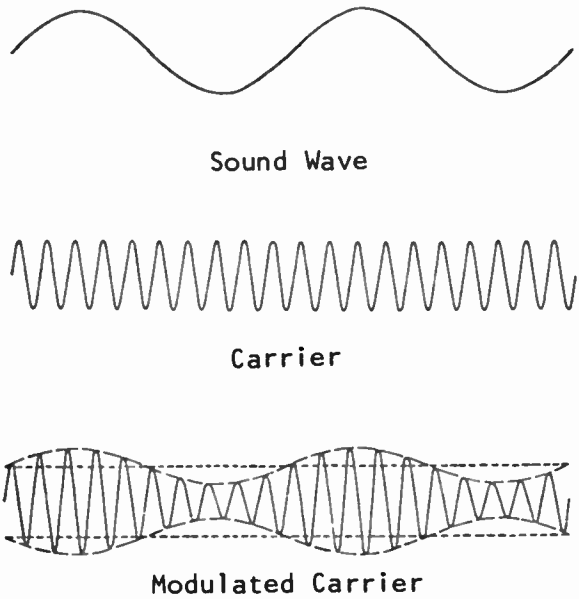

Figure 2-7 Amplitude modulation

After the radio wave has been modulated, it is amplified and then radiated into space by an antenna. A receiver extracts the information contained in the modulated waveform. The receiver performs three functions. First, it separates the desired carrier from others by a tuning operation in which the receiver is made sensitive only to radio waves having the desired frequency. Second, the receiver removes the carrier and keeps only the modulation waveform that represents the desired information. This is the detection process. Third, the receiver amplifies the modulation and applies it to a loudspeaker where it is reproduced as sound.

The process of amplitude modulation causes the radio frequency carrier to be spread over a band of frequencies equal to twice the modulation frequency. For AM broadcasting the highest modulation frequency is normally limited to 5,000 Hz or slightly less than twice the bandwidth of a telephone voice circuit. Even so, this means that a single station will occupy a segment of the radio frequency spectrum that is 10 kHz wide, centered on the assigned carrier frequency. If any other radio station broadcasts within the band or near enough so that its modulation components fall in this band, there will be interference between the two stations.

To minimize interference between stations the Federal Communications Commission was given authority to allocate the spectrum by means of licensing procedures. Unfortunately, sufficient space is not available in the radio spectrum to meet all of the demand and less than ideal operations result. This is apparent when tuning over the AM broadcast band at night when the problem of overcrowding is severely aggravated because of the increased transmission distances that result from changes in the earth's ionosphere after sunset. The interference problem can be partially solved by restricting some broadcast stations to daytime broadcasting only, or by requiring reduced power at night. As a further solution to the problem of interference among stations having the same assigned carrier frequencies, 39 clear channels have been established in the western hemisphere on which only one station broadcasts. These channels are widely dispersed geographically and assure interference-free reception in their primary coverage areas. This course of action is only possible to a limited extent because, if the entire broadcast band covering 535 to 1605 kHz were allocated on this basis, there could only be (1605 - 535) ÷ 10 = 107 stations. Actually, there are thousands

of AM stations, and, therefore, interference. The problem is particularly bad at geographical locations outside the primary coverage area of stations, because there many signals on the same frequency may be received simultaneously with more or less equal power and they interfere with each other.

FM Broadcasting

One of the major disadvantages or limitations of AM radio is its sensitivity to electrical disturbances of both natural and man-made origin. Such disturbances manifest themselves as static and result from such things as lightning, neon signs, and electric razors. Most natural and man-made electromagnetic disturbances add to the signal at the receiver and so are detected as a change in the amplitude and are superimposed on the true signal contained in the modulation.

In the 1930's Major Edwin H. Armstrong devised a way to virtually eliminate the susceptibility of radio signals to static that so severely limits AM broadcasting. He did this by changing the way in which he modulated the carrier. Instead of varying the amplitude of the carrier, Armstrong kept the amplitude constant and varied the frequency. Figure 2-8 illustrates the frequency modulation of a carrier. The great improvement in noise performance comes because the receiver can now be made insensitive to amplitude variations caused by static. It does this by ignoring the amplitude variations and looking only for the frequency variations which are virtually unaffected by static. The technique works effectively and eliminates the static so prevalent in AM broadcasting.

As we might expect, a price must be paid for improved performance, and the price in this case is increased bandwidth. Frequency modulation obtains its improved performance by requiring a larger segment of the radio spectrum to transmit

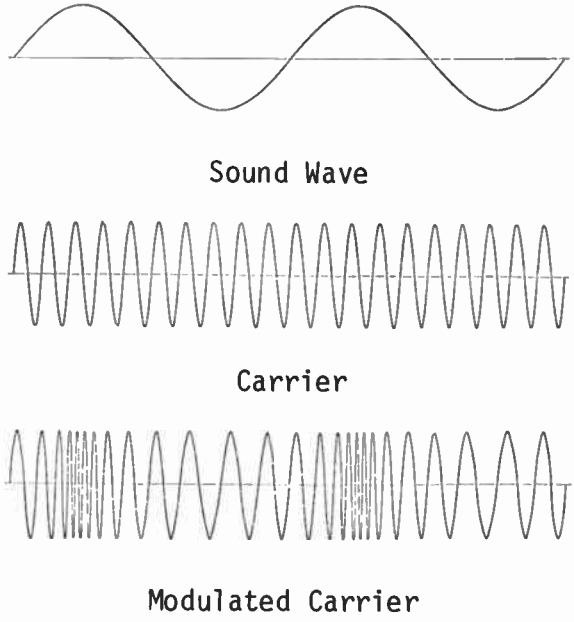

Figure 2-8 Frequency modulation

the same information. In commercial FM broadcasting the ratio of transmission bandwidth to modulating signal bandwidth is about 10:1, compared with 2:1 for AM broadcasting. Because of the noise-free performance possible with FM broadcasting, the FCC decided to permit a larger bandwidth of modulation to be used so that higher quality music reproduction would be possible. The modulation bandwidth of commercial FM broadcast stations is 15 kHz which covers the range of most of the sounds heard by the human ear. The bandwidth of the transmitted signal is, therefore, 10 x 15 = 150 kHz, which is 15 times greater than that employed in AM broadcasting. In order to minimize interference between stations on adjacent frequencies, a separation of 200 kHz is used between channels. The FM broadcast band employed in the U.S. and Canada is from 88 to 108 MHz, which lies

between television channels 6 and 7. This band provides 100 separate FM channels. Radio wave propagation on such high frequencies is limited to line-of-sight distances, so FM broadcasting has a 40- to 80-mile radius of coverage under normal operating conditions. If FM broadcasting were carried out in the AM broadcast band, only five stations could be accommodated on the entire band. For this reason FM broadcasting is carried out at higher frequencies where more bandwidth can be made available.

Television Broadcasting

The concept of television broadcasting is simple. Imagine a picture or scene with a small, light-sensing telescope that can be pointed at various parts of the scene. The output of the telescope is an electrical signal proportional to the intensity of the scene in the direction that the telescope is pointing. As the telescope is moved along a horizontal line the signal will vary as the scene intensity varies along the line. This electrical signal amplitude-modulates a carrier which is radiated to a receiver where the wave is demodulated. The information on scene brightness is sent to a light source that moves in synchronism with the sensing telescope at the pickup location. When the scene brightness increases, the light intensity increases, and when the scene brightness decreases, the light intensity decreases. Thus, as the telescope moves over the scene at the pickup location, the light at the receiver moving in synchronism with it paints out the same variations of lightness and darkness as the original scene. By doing this very rapidly (e.g., broadcast TV traces the complete picture 30 times per second) the eye in effect "sees" a continuous scene without any apparent motion of the scanning light source.

Figure 2-9 shows a schematic representation of this process. In an actual television system, the moving light on the receiver is an electron beam illuminating the phosphorent screen of a cathode ray tube and the image pickup device is a special television sensor called an image orthocon.

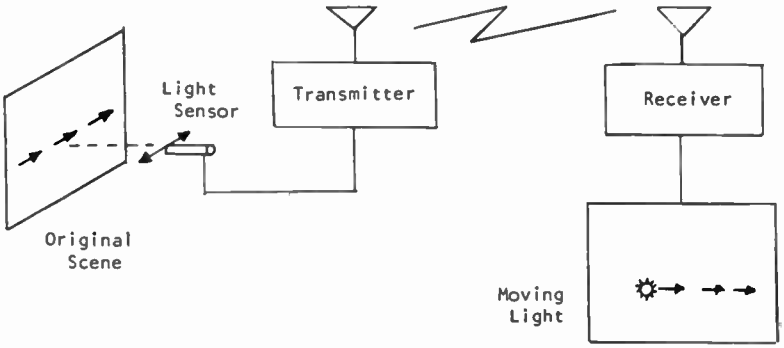

Figure 2-9 Elementary television system

In a typical (American) television system there are 525 lines in the picture and 30 complete frames per second. The horizontal to vertical aspect ratio (i.e., the ratio of width to height) is 4:3. A standard TV picture has approximately 165,000 distinct picture elements (pixels) and when such pictures are reproduced 30 times per second, they occupy a signal bandwidth of 4 MHz. American TV employs a special type of amplitude modulation that utilizes much less bandwidth than conventional AM modulation 1.1:1 as compared to 2:1. When additional spectrum is added for FM transmission of the sound to accompany the picture and a small guard space between channels is included, the total bandwidth requirement is 6 MHz for a single television channel. This is nearly six times the bandwidth of the entire AM broadcast band and the entire FM broadcast band would accommodate only three TV channels. The frequencies utilized for

television broadcasting are shown in Table 2-3. The noncontiguous spacing of the VHF channels is not happenstance but intentionally done to minimize certain kinds of interference that can result when the channels are all adjacent to each other. (4)

Table 2-3 Television channel frequencies

Channel	Frequency (MHz)	Remarks
2, 3, 4	52-72	VHF low band
5, 6	76-88	VHF low band
7-13	174-216	VHF high band
14-83	470-890	UHF

Video Telephone

The videotelephone as implemented by the Bell System in its Picturephone® is a miniature television system. The screen size is 14 cm x 12.7 cm (5½ in. x 5 in.). There are 250 lines per frame and 30 frames per second. The number of picture elements in the image is substantially less than that of commercial TV and also the number of gray shades is smaller. Because fewer elements need be transmitted each second, it requires less transmission bandwidth. The Picturephone® requires only a 1 MHz bandwidth for satisfactory picture reproduction. By comparison, this bandwidth would accommodate 250 voice circuits.

Pulse Code Modulation

In recent years a new type of modulation has become very important for a wide variety of communications other than broadcasting. This new type of modulation is called pulse code modulation or PCM.

It is of particular interest in a general discussion of telecommunications because it provides a simple method of representing general signals in terms of the elementary form of binary digits or bits. The key concepts required in the understanding of PCM are those of *sampling* and *quantization*. Sampling means measuring the amplitude at equally spaced intervals called the *sampling period*. Quantization is the process of assigning the actual amplitude to the closest one of a predetermined set of (usually) equally spaced amplitude levels. Figure 2-10 illustrates the sampling and quantization of a waveform.

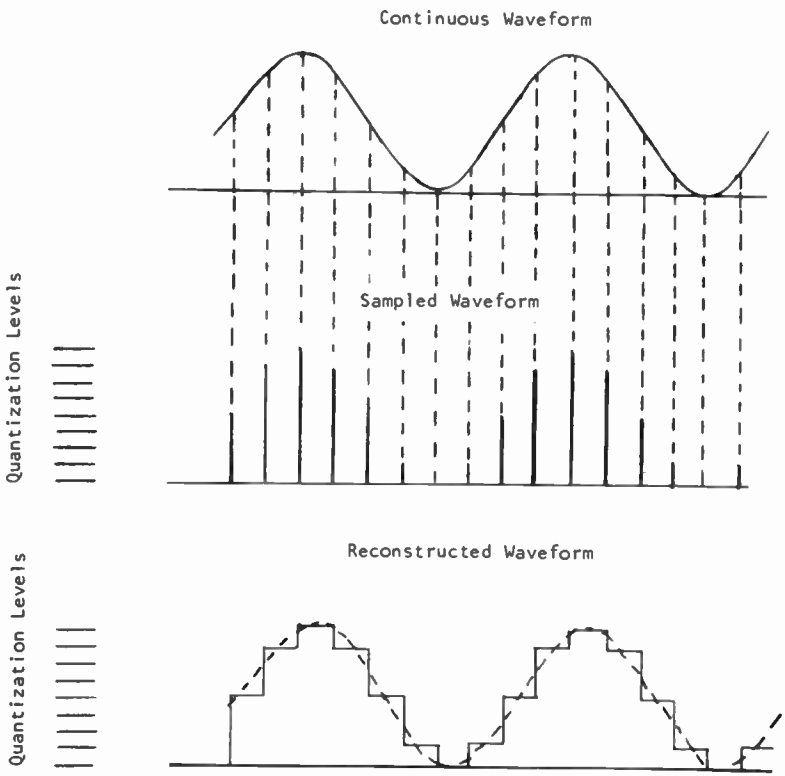

Figure 2-10 Sampling and quantization

Once the sampling and quantization has been done, it is possible to describe the result completely by a sequence of numbers. The first number is the quantum level of the first sample, the second number is the quantum level of the second sample, etc. More importantly, this procedure allows a continuous waveform to be transmitted over a communication channel as a set of discrete numbers as opposed to a continuous or analog waveform. A simple way of transmitting the numbers representing the quantum levels is by means of a binary code similar to that used by a teletypewriter. Examples of 8-level and 16-level binary codes are shown in Table 2-4. The order of the

Table 2-4 Binary codes

Number	3-bit Code	4-bit Code
1	000	0000
2	001	0001
3	010	0010
4	011	0011
5	100	0100
6	101	0101
7	110	0110
8	111	0111
9		1000
10		1001
11		1010
12		1011
13		1100
14		1101
15		1110
16		1111

binary digits determines the number that is represented. Generally, the number of different quantum levels that can be represented by a binary code with N digits is two raised to the Nth power. Thus a 4-bit binary code would correspond to 2^4 = 16 levels and a 10-bit code would correspond to 2^{10} = 1024 levels. An illustration of a quantized waveform is shown in Figure 2-11 along with the 3-bit code sequence that would represent the first six samples.

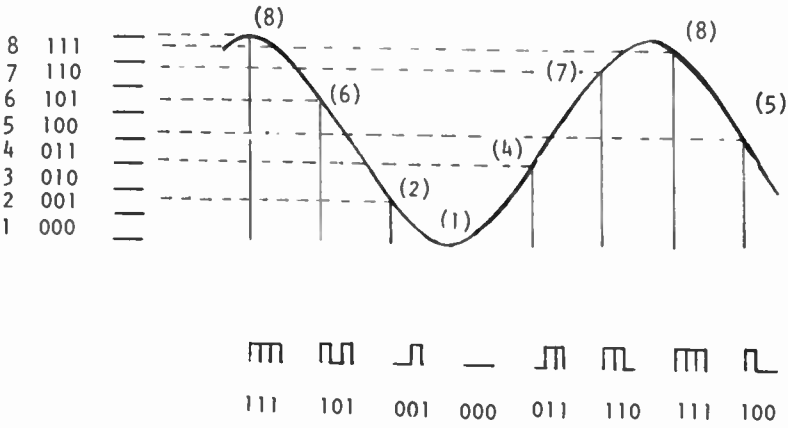

Figure 2-11 PCM signal

The number of quantum levels required depends on the fidelity with which it is necessary to reproduce the original waveform. If too few levels are used, noticeable distortion occurs. If too many levels are used, no further improvement is obtained because noise in the transmission introduces distortions larger than the incremental errors of the quantization.

The rate of transmission required for pulse code modulation can be obtained by multiplying the number of bits in the code words used to represent the function levels by the number of samples per second. The sampling rate is always taken as twice

the signal bandwidth to permit undistorted reproduction of the waveform. This can be expressed in symbols as T = 2WN: where T is the transmission rate in bits per second; W is the bandwidth of the signal in Hz; and N is the number of bits in the code words. The PCM transmission rates required for transmission of typical telecommunication signals is shown in Table 2-5. It is interesting to note from Table 2-5 that with PCM the transmission rate of Picturephone® signals is only 100 times the rate of a voice channel compared with 250 times for analogue transmission.

Table 2-5 PCM transmission rates

Signal	B.W.	Bits/Code Word	Bit Rate
Telephone	4 kHz	7	56 k bits/s
Hi-Fi music	15 kHz	10	300 k bits/s
Picturephone®	1 MHz	3	6 M bits/s
Color TV	4.6 MHz	10	92 M bits/s

The primary attractions of PCM are its inherent insensitivity to noise since only on-off type signals are transmitted and the ease with which the signal can be exactly regenerated during transmission over long distances. Also, the format of PCM is closely related to that of computer data and can be transmitted over the same channels using the same equipment.

Channel Capacity and Multiplexing

Much effort has been expended over the years in expanding the capacity of communication systems. Figure 2-12 shows how this growth has proceeded over the past 125 years. It is evident from the figure that channel capacity is increasing at a phenomenal rate--by a factor of 10 times each 18

years. If this pace continues, and there is every reason to believe that it will, the capability of greatly expanded telecommunications services will be at hand almost immediately.

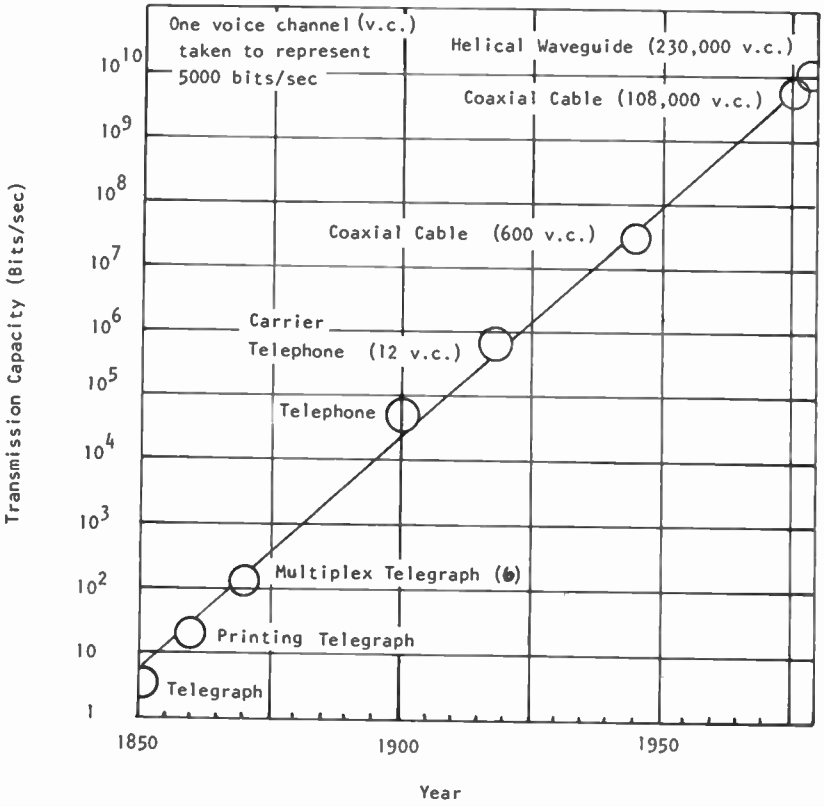

Figure 2-12 Development of telecommunications channel capacity (Adapted from J. Martin, *Telecommunications and the Computer*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1969).

In order to make good use of large capacity channels, it is necessary to combine many separate signals and send them together over a single channel. This is called multiplexing and is done in

many ways. Two of the most common methods are frequency division multiplexing (FDM) and time division multiplexing (TDM).

Frequency division multiplexing is accomplished by modulating the individual signals onto carriers having different frequencies (thus the name) and then sending them over a common channel. This is analogous to transmitting the radio broadcast band over a cable with each station carrying the modulation corresponding to one of the individual signals. The signals are separated at the receiving end of the channel by frequency selective filters in the same manner that a radio separates one station from another.

In time division multiplexing, samples from different signals are intermixed before transmission. For example, eight signals could be transmitted by sending in sequence the first sample of signal one followed by the first sample of signal two on up to the first sample of signal eight. Then the second samples of each would be sent. This process can be extended to include hundreds or even thousands of distinct signals. The signals are separated at the output of the channel by keeping track of the times that samples from a particular signal are being sent (called synchronization) and switching these samples to the proper location for that message. An example of a TDM system is the Bell System T1 digital data transmission system. It consists of the regular twisted pair of telephone wires but with closely spaced repeaters. It is capable of handling 24 speech channels of 8 bits quantization. This corresponds to 2 WN x 24 = 2 x 4000 x 8 x 24 = 1.5 million bits/sec. The next planned system, the T2 carrier, would operate at a bit rate of 6.3 M bits/sec and could accommodate four T1 carriers or one picture phone signal.

Typical Information Source Data Rates

The human mind and body are only able to accommodate inputs at relatively low rates, nothing like the rates presently possible in telecommunication channels. For instance, consider the information rate of human reading. A fast reader might cover as many as 1,000 words per minute. This corresponds to 83 letters per second or 415 bits per second. Display screens available today for presenting printed text operate at 2,400 bits per second, more than five times reading speed. Computer printers, the devices that produce the hard copy output, can generate 1,200 lines per minute which is 20,000 bits per second. This is also the speed at which IBM cards can be read.

A PCM voice channel with 4 kHz bandwidth and 8-bit quantization generates 64,000 bits per second. Note the great discrepancy of more than 150:1 between the required transmission rates for reading and talking. If the word content of a message was all that was important, it would be possible to improve communication efficiency greatly by using teleprinting instead of telephoning. Actually, the other aspects of speech communication such as voice inflections, familiarity, personal awareness, etc., provide dimensions not readily obtainable in the printed words or artificial generation of speech at remote locations.

High fidelity sound reproduction represents a substantial increase in data rate for the communication channel. For a bandwidth of 20,000 and a quantization level of 10 bits to assure high quality reproduction, the transmission rate would be 2 x 10 x 20,000 = 400,000 bits/sec. The next step beyond high fidelity sound reproduction is television. For commercial television with 525 lines resolution the required bandwidth is 4 MHz and with 10 bit quantization this corresponds to 2 x 10 x 4 = 80 megabits per second. This is equiva-

lent to about 1,200 voice channels, and this tradeoff is what actually occurs in satellite and intercity communication channels used to handle both television signals and telephone signals.

Telecommunication Channels: Present and Future

Telephone communication between cities makes use of coaxial cables and microwave relays. A coaxial cable consists of a copper tube with a wire running down its center. Usually there is insulating material between the outer tube and the inner conductor. This material keeps moisture out of the tube and holds the center conductor in the middle of the tube, which is necessary for proper operation. The coaxial cable is used to carry electromagnetic (radio) waves from one place to another. The waves all stay inside the tube and can be amplified or switched to other channels as required. The primary limitations of the coaxial cable are its bandwidth and the attenuation of signals that necessitates amplification at short intervals. A modern coaxial cable can handle nearly 5,000 voice channels. Typically a number of cables are bundled together and installed underground as a communication trunk. Figure 2-13 shows 1973 coaxial cable installation and a cross-sectional view of a trunk having a 108,000-voice channel capacity.

Microwave relays use signals radiated through the atmosphere from antennas on one tower to antennas on another tower. By using very high carrier frequencies, about 4 to 6 GHz, it is possible to obtain large bandwidths and simultaneously restrict the radiation to narrow paths so it will not interfere with others using these same frequencies. The technology in these systems grew from radar developments during World War II. The

Figure 2-13 Installation of a coaxial cable in the Mississippi River. Bell Labs Photo.

early systems built during the 1940's carried a few hundred voice circuits; today a microwave relay operating simultaneously on two carrier frequencies can accommodate as many as 29,000 voice channels. When current systems are further modernized, it is anticipated that the capacity will be increased to 34,800.(5) Figure 2-14 shows a modern microwave relay tower used for intercity telecommunications.

The next step in long distance transmission was the communication satellite which came into serv-

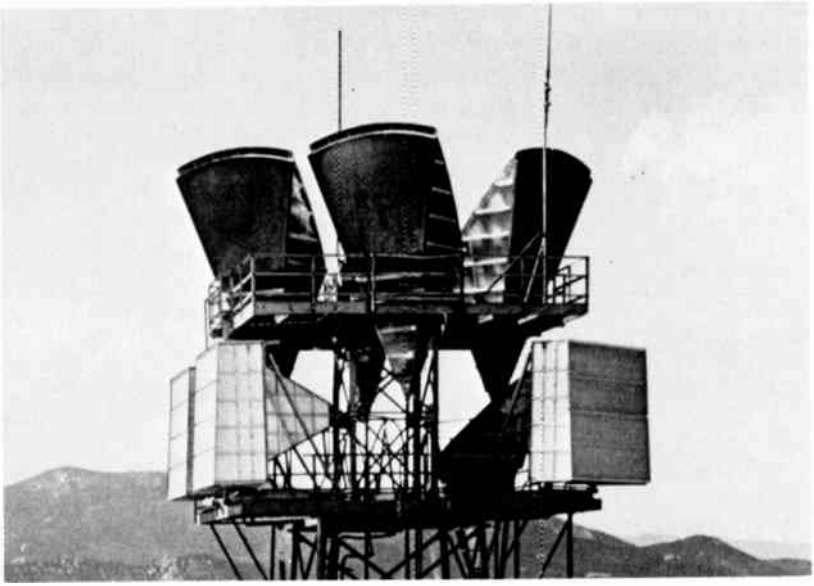

Figure 2-14 Microwave relay tower. Western Electric News Features.

ice in the 1960's. Satellites are discussed in considerable detail in Chapter 5 and will not be considered here except to note for purposes of comparison with microwave relay, that the domestic communication satellites scheduled for operation in 1976 will have 14,400 voice channels each and will be accessible from several different ground stations.

The next major developments in surface transmission of data may be the circular waveguide and the optical fiber. The waveguide is essentially a hollow pipe built to precise tolerances that guides radio waves from one point to another with very low attenuation. Signals can be transmitted via waveguide for 32 km (20 miles) before they must be amplified whereas for signals in coaxial cables there must be amplifiers every 3.2 km (2 miles). Because they operate with very high car-

rier frequencies, (40 to 110 GHz) it is easy to obtain very large bandwidths. Installation of the first experimental system was begun in 1975 over a 13.7 km (8.5 mile) segment in northern New Jersey. This system will have an initial capacity of 230,000 voice channels, a capacity which will ultimately be expanded to 460,000 voice channels. Figure 2-15 shows a segment of waveguide being installed.

Figure 2-15 Section of circular waveguide being installed. Bell Labs Photo.

Thus it is clear that the achievement of increased bandwidth is closely tied to higher carrier frequencies. The ultimate step in this direction appears to be the use of light waves as carriers of communication signals. The frequency of electromagnetic radiation corresponding to visible light is thousands of times greater than that of the highest frequency radio waves presently used for communication, and the available bandwidths are correspondingly larger.

Two developments in recent years have made optical communications feasible. The first is the laser, a powerful generator of pure and high power light waves. The second is the optical waveguide, a specially constructed glass fiber smaller in diameter than a human hair, that can conduct light from one point to another with low attenuation. Ultimately, these developments may lead to systems having Gigabit per second capabilities in a single fiber. A bundle of several hundred such fibers would only be the size of a pencil, but would provide a communication channel far better than any existing today. Very likely fibers will find their way into the home and office in the not too distant future as a broadband communication channel to serve a wide variety of needs. Figure 2-16 shows a bundle of optical fibers.

Solid State Electronics

While the evolution in transmission capacity of communication channels has been occurring, enormous and revolutionary changes have been occurring in the field of electronic devices and components. Development of what is generally called solid state technology brought about these changes. Extensive research on electronic applications of crystals as detectors of electromagnetic radiation was carried out during World War II. This work continued after the war and led to development, in

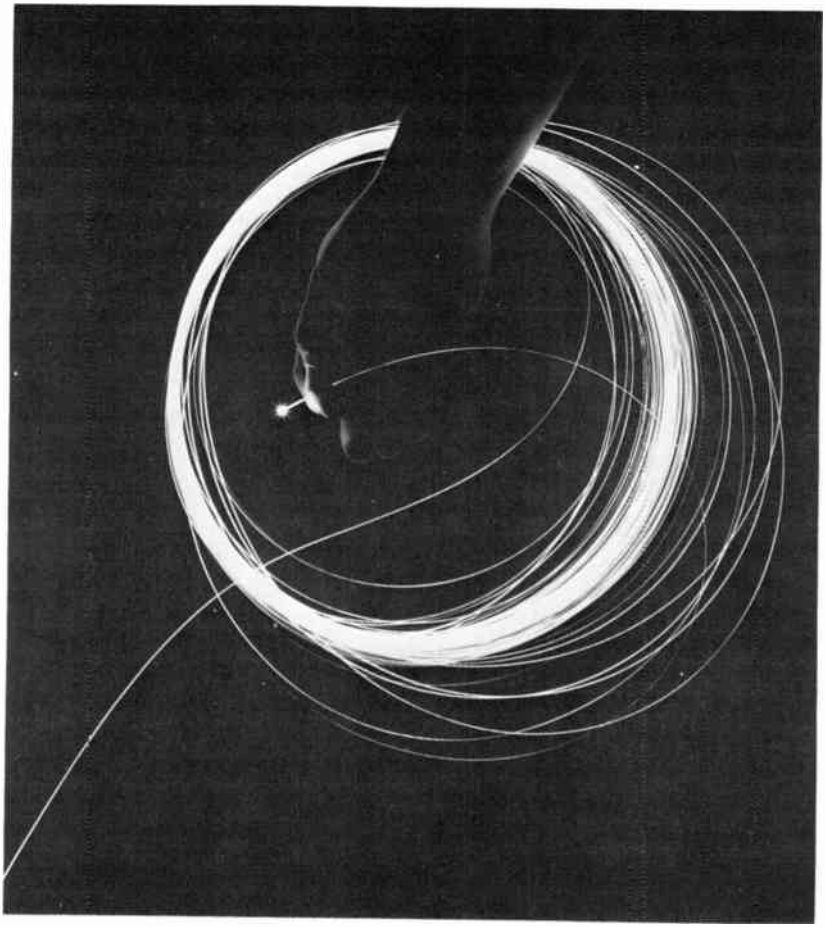

Figure 2-16 Optical transmission line. Bell Labs Photo.

1947, of an entirely new kind of electronic amplifier, the transistor. This small device did not require the electrical heating element necessary to all vacuum tubes. From its inception this new device was destined to have a major impact on the entire electronics industry.

Initially, the transistor could not compete in any significant way with the vacuum tube. However,

by the middle 1950's sufficient advances had been made in solid state technology so that transistors could be produced that were more than competitive with vacuum tubes. This was particularly true for military electronic applications where small size, ruggedness, and reliability were of utmost importance. The rapid development of solid state technology during the 1950's was due in large measure to research and development efforts sponsored by the Department of Defense.

Because of the inherently small size of transistors, producing miniaturized electronic components and subassemblies was emphasized. These developments progressed until "integrated circuits," transistors and their associated components and interconnections, were simultaneously produced in a small package as a complete functional unit. Instead of a transistor, one could purchase a complete amplifier or other component. Frequently, the cost of these complete units was many times less than that of a single transistor a few years earlier. "Throw-away" portable radios became a reality, radios, which could be purchased for less than ten dollars and discarded if they were damaged or failed for some other reason. The cost of repairing them exceeded their replacement cost.

The transistor and its successor, the integrated circuit, found instantaneous acceptance in the field of electronic computers. It is safe to say that without solid state technology the computer would not be the pervasive influence in our society that it is today.

Another step in subminiaturization of electronic components occurred with development of the capability of making large scale integrated circuits (LSI). With this technique literally thousands of transistors and associated components would be placed in postage-stamp size packages. This led to such new consumer products as pocket calculators and digital wrist-watches. Figure 2-17 shows a

programmable pocket calculator that can remember up to 100 instructions given it by the operator.

Figure 2-17 Programmable pocket calculator

This unit contains the equivalent of 70,000 transistors. More important, however, LSI technology has greatly reduced the size and cost of large capacity digital computers and other complex electronic equipment and systems. Without integrated circuits and the wide variety of other solid state technology that has developed in the past two decades, it is unlikely that we would have communication satellites, electronic switching systems, or nearly the communication capacity that exists in the world today. Through this technology, telecommunications services are being made available throughout the world at costs that put them within reach of large segments of the world's population that have never had anything like these services until now.

Future Technological Developments

The advent of inexpensive telecommunications devices and systems based on solid state technology foretells developments of great potential within the next few decades. The two most obvious trends are the continually expanding use of the computer throughout government, business, and society in general, and the greatly reduced cost and increased availability of long distance telephone communication. Other directions of technological innovation are equally as interesting.

The technological potential exists for the wired city to become a reality. The transmission of telecommunications signals between fixed locations does not require use of radiated electromagnetic energy as in radio and television broadcasting. Such signals can be carried more efficiently, though not now less expensively, by cables or other transmission lines than by radiated signal. Carriage of signals between transmitter and receiver would free major portions of the radio spectrum for other use. Potentially the number of channels

and the bandwidths available could far exceed anything possible by means of directly radiated signals. Also, talk-back facilities could be readily provided for a variety of purposes ranging from computer-aided instruction to voting. A 1975 study described possible services that could be provided in the home by a wideband telecommunications terminal.(6) Estimates of the probable interest and usage of such services and when they might be introduced to society were obtained from experts using the Delphi technique of technology forecasting. See Tables 2-6 and 2-7 for a list of potential services and forecasts. Although assessing the accuracy of such predictions is difficult, appreciating the enormous potential for such technological development is easy.

Other developments ranging from pocket telephones to automatic automobile driving and computer diagnosis of ailments are easily imagined. But predictions can go awry, because many forces other than technological feasibility can strongly influence the course of development. These forces are economic, social, and political, and their impact on technological development will be the concern of much of the next three chapters. Only after examining these forces in detail will a return to consideration of the continuing evolution of telecommunications technology and its impact on society be possible.

Table 2-6 Brief descriptions of potential home information services (6)

1. CASHLESS-SOCIETY TRANSACTIONS. Recording of any financial transactions with a hard copy output to buyer and seller, a permanent record and updating of balance in computer memory.

2. DEDICATED NEWSPAPER. A set of pages with printed and graphic information, possibly including photographs, the organization of which has been predetermined by the user to suit his preferences.

3. COMPUTER-AIDED SCHOOL INSTRUCTION. At the very minimum, the computer determines the day's assignment for each pupil and, at the end of the day, receives the day's progress report. At its most complex, such a service would use a real-time, interactive video color display with voice input and output and an appropriate program suited to each pupil's progress and temperament.

4. SHOPPING TRANSACTIONS (STORE CATALOGS). Interactive programs, perhaps video-assisted, which describe or show goods at request of the buyer, advise him of the price, location, delivery time, etc.

5. PERSON-TO-PERSON (PAID WORK AT HOME). Switched video and facsimile service substituting for normal day's contacts of a middle class managerial personnel where daily contacts are of mostly routine nature. May also apply to contacts with the public of the receptionist, doctor, or his assistant.

6. PLAYS AND MOVIES FROM A VIDEO LIBRARY. Selection of all plays and movies. Color and good sound are required.

7. COMPUTER TUTOR. From a library of self-help programs available, a computer, in an interactive mode, will coach the pupil (typically adult) in the chosen subject.

8. MESSAGE RECORDING. Probably of currently available type, but may include video memory (a patient showing doctor the rash he has developed).

9. SECRETARIAL ASSISTANCE. Written or dictated letters can be typed by a remotely situated secretary.

10. HOUSEHOLD MAIL AND MESSAGES. Letters and notes transmitted directly to or from the house by means of home facsimile machines.

11. MASS MAIL AND DIRECT ADVERTISING MAIL. Higher output, larger-sized pages, color output may be necessary to attract the attention of the recipient--otherwise similar to item 10, above.

12. ANSWERING SERVICES. Stored incoming messages or notes whom to call--possibly computer logic recognizing emergency situation and diverting the call.

13. GROCERY PRICE LIST, INFORMATION, AND ORDERING. Grocery price list is used as an example of up-to-the-minute, updated information about perishable foodstuffs. Video color display may be needed to examine selected merchandise. Ordering follows.

14. ACCESS TO COMPANY FILES. Information in files is coded for security: regularly updated files are available with cross-references indicating the code where more detailed information is stored. Synthesis also may be available.

15. PARTS AND TICKET RESERVATION. As provided by travel agencies now but more comprehensive and faster. Cheapest rates, information regarding the differences between carriers with respect to service, menus, etc. may be available.

16. PAST AND FORTHCOMING EVENTS. Events, dates of events, and their brief description, short previews of future theater plays, and recordings of past events.

17. CORRESPONDENCE SCHOOL. Taped or live high school, university, and vocational courses available on request with an option to either adult or graduate. Course on TV, paper support on facsimile.

18. DAILY CALENDAR AND REMINDER ABOUT APPOINTMENTS. Prerecorded special appointments and regularly occurring appointments stored as a programmed reminder.

19. COMPUTER-ASSISTED MEETINGS. The computer participates as a partner in a meeting, answering questions of fact, deriving correlations, and extrapolating trends.

20. NEWSPAPER, ELECTRONIC, GENERAL. Daily newspaper, possibly printed during the night, available in time for breakfast. Special editions following major news breaks.

21. ADULT EVENING COURSES ON TV. Noninteractive, broadcast mode, live courses on TV -- wider choice of subjects than at present.

22. BANKING SERVICES. Money orders, transfers, advice.

23. LEGAL INFORMATION. Directory of lawyers, computerized legal counseling giving precedents, rulings in similar cases, describing jurisdiction of various courts and changes of successful suits in a particular area of litigation.

24. SPECIAL SALES INFORMATION. Any sales within the distance specified by the user and for items specified by him will be "flashed" onto the home display unit.

25. CONSUMERS' ADVISORY SERVICE. Equivalent of Consumer Reports, giving best buy, products rated "acceptable," etc.

26. WEATHER BUREAU. Country-wide, regional forecasts or special forecasts (farmers, fishermen), hurricane and tornado warnings similar to current special forecast services.

27. BUS, TRAIN, AND AIR SCHEDULING. Centrally available information with one number to call.

28. RESTAURANTS. Following a query for a type of restaurant (Japanese, for instance), reservations, menu, prices as shown. Displays of dishes, location of tables, may be included.

29. LIBRARY ACCESS. After an interactive "browsing" with a "librarian computer" and a quotation for the cost of hard copy facsimile or a show-scan video transmission, a book or a magazine is transmitted to the home.

30. INDEX, ALL SERVICES SERVED BY THE HOME TERMINAL. Includes prices or charges of the above, or available communications services.

Table 2-7 Summary of Median forecasts (6)

Service	Average $ Value of One Conversation Low	Middle	High	Duration of Single Transaction (min.)	Data Transmission Connect Time (%)	Avg. No. of Transactions/ Mo./Home
1. Cashless society transactions	$0.10	$0.16	$ 0.40	0.75	20%	40
2. Dedicated newspaper	0.10	0.20	0.50	10.00	95	30
3. Computer-aided school instruction	0.50	1.50	3.50	30.00	20	20
4. Shopping transactions (store catalogs)	0.20	0.50	1.00	6.00	40	10
5. Person-to-person (paid work at home)	0.50	1.50	5.00	20.00	50	60
6. Plays and movies from video library	0.60	2.00	5.00	90.00	100	10
7. Computor tutor	1.00	2.00	5.00	30.00	20	10
8. Message recording	0.20	0.35	1.00	3.00	75	7
9. Secretarial assistance	0.35	1.00	3.00	10.00	60	10
10. Household mail and messages	0.10	0.20	0.50	2.00	90	25
11. Mass mail and direct advertising mail	0.10	0.17	0.50	3.00	90	25
12. Answering services	0.10	0.20	0.50	2.00	80	20
13. Grocery price list, information, and ordering	0.20	0.35	0.50	5.00	80	15
14. Access to company files	0.30	0.60	2.00	5.00	65	10
15. Fares and ticket reservation	0.20	0.35	0.75	5.00	50	5
16. Past and forthcoming events	0.10	0.20	0.50	4.00	80	10
17. Correspondence school	1.00	2.00	5.00	40.00	85	10
18. Daily calendar and reminder of appointments	0.10	0.20	0.50	1.00	80	25
19. Computer-assisted meetings	1.00	2.00	5.00	30.00	40	5
20. Newspaper, electronic, general	0.20	0.50	0.75	10.00	95	30
21. Adult evening courses on television	0.60	1.00	5.00	50.00	95	10
22. Banking services	0.10	0.25	0.50	2.00	60	20
23. Legal information	1.00	5.00	15.00	10.00	75	5
24. Special sales information	0.20	0.50	1.00	4.00	70	10
25. Consumers' advisory service	0.25	0.50	1.00	5.00	70	10
26. Weather bureau	0.10	0.20	0.50	1.00	90	20
27. Bus, train, and air scheduling	0.10	0.20	0.50	1.25	80	5
28. Restaurants	0.10	0.20	0.50	3.00	80	5
29. Library access	0.50	1.00	2.00	10.00	90	5
30. Index, all services	0.10	0.20	0.50	3.00	80	10

% of Service Home Subscriber Expected to Pay	Most Likely Year of Introduction			% Penetration of All U.S. Households	Median Transmit Time (min.)	Average Value of Service, $/Subscribing Household/Mo.		Value of Service After 5 Years, $/Average U.S. Household/Mo. (At Penetration Rates Shown)
	Early	Middle	Late			Median	High	
25%	1975	1980	1990	20%	0.19	$ 6.4	$ 12.50	$ 1.00
75	1980	1983	1990	10	9.00	6.0	15.00	0.54
50	1975	1982	1987	10	10.00	40.0	100.00	3.75
25	1977	1985	1990	10	2.50	3.0	5.00	0.38
5	1980	1985	1990	5	6.50	75.0	250.00	3.20
80	1975	1980	1985	10	90.00	20.0	50.00	2.00
80	1975	1980	1990	5	6.00	20.0	50.00	1.50
90	1975	1980	1985	10	2.50	2.5	6.25	0.20
100	1975	1980	1985	5	6.00	10.0	25.00	0.25
75	1980	1985	1990	10	1.80	5.0	12.00	0.60
0	1980	1990	1995	10	2.55	4.0	15.00	0.50
100	1975	1980	1985	10	1.60	5.0	11.25	0.30
50	1975	1980	1990	10	4.25	5.0	7.50	0.26
1	1980	1985	1990	2	3.50	15.0	50.00	0.30
40	1975	1980	1985	5	2.50	1.0	2.50	0.05
50	1975	1982	1990	5	2.70	2.0	5.00	0.11
75	1978	1984	1990	5	30.00	20.0	50.00	0.75
100	1980	1983	1985	5	0.95	4.0	10.00	0.20
40	1975	1980	1985	5	6.00	15.0	91.00	0.75
75	1980	1985	1990	5	9.00	15.0	22.50	0.75
80	1975	1980	1985	10	45.00	10.0	25.00	0.88
60	1975	1980	1985	10	0.85	4.0	10.00	0.38
100	1980	1985	1990	3	7.50	6.0	25.00	0.25
80	1975	1982	1990	5	2.70	5.0	10.00	0.25
100	1975	1980	1985	5	3.50	7.5	10.00	0.40
100	1975	1980	1980	5	0.90	2.0	5.00	0.12
80	1975	1977	1980	5	1.00	0.5	1.00	0.06
60	1975	1980	1985	5	2.50	1.0	2.50	0.05
100	1980	1985	1990	5	9.00	5.0	10.00	0.25
50	1975	1980	1985	5	2.50	3.0	5.00	0.10
								$20.12

Chapter 3

Politics, Economics, and Telecommunications Technology

One major set of factors that strongly influences growth or retardation of technological development is the political and economic systems within which such development occurs. It is the political system that determines which interests receive encouragement and which are deterred from various actions. The policies which are made by portions of the government directly affect which technologies will be used for particular services, which technological developments will be encouraged, and which will not be fostered.

Economic considerations also provide direction for the development and use of telecommunication technology. Operating in a free market would provide the telecommunications industry with many guides about what services would be acceptable to the largest markets, at what prices. Such directions would certainly influence the industry's development of new technologies, utilization of existing ones, and provision of services. However, the marketplace does not always operate freely or perfectly, and the role of government regulation of the market and the industry has substantially altered these kinds of parameters for the operation of the industry. While the book will discuss these economic considerations as part of the examples covered in Chapters 4 and 5, it is useful to explore some of the general economic considera-

tions in this chapter, before more detailed discussions.

The chapter will present a general model for political decision making which will provide a basis for the analysis of particular cases which follow in subsequent chapters. No social science model can be precise, and many cannot suggest casual relationships. The model developed here is presented only as one way in which techno-political decisions (political decisions relating to technology) can be viewed. It should provide a perspective from which the development of telecommunications technology can be considered.

Politics

Politics has been defined in a variety of ways, but it has one widely recognized definition: It is the authoritative allocations of values for a society.(1) This definition contains several important points about the political scene.

First, politics is an *allocating process* by which a variety of scarce values are allocated or distributed among members of contending factions of society. There are other allocative processes, such as the economic marketplace. However, some items cannot be allocated by selling them to the highest bidder. Either because a price cannot be fixed for some items or because people feel a nonmarket procedure would result in a more equitable distribution of a good, the political process is given the responsibility for many allocations in a society.

Second, the political process results in an *authoritative* allocation, one that the population will respect and abide by. The authoritativeness of a governmental allocation may depend on agreement with the allocation by members of society, or on the physical force which the government can bring to bear on recalcitrants to accept

the decision. Generally, however, the authoritativeness of a decision rests on a general level of support for the government, its institutions, and the current officials which go beyond the particulars of the immediate decision. Thus, most people accept most government decisions, even if some people do not agree with the decisions or benefit as a result of them.

Lastly, the allocation process operates on *values* in the society. This means that whatever the society places value on-- money, prestige, or sea shells--can be allocated by governmental processes. The entire allocation process can be considered as one of allocating resources, as long as the term "resource" is viewed in general terms. In the telecommunications setting, the kinds of resources which government allocates include radio spectrum for broadcasting and other uses, money in the form of government research and development contracts, and permissible rates which companies can charge for providing services to the general public. These resources are not the only ones the government allocates, but they suggest the variety of items allocated. In general, the participants in the allocation process view the resource involved as important and frequently valuable. The kinds of resources allocated will be illustrated throughout this book, and will demonstrate the dimensions of governmental operation.

Political Arenas

A government is formed of institutions which are designed to make the allocations discussed above. The institutions are outlined by a constitution, and the major importance of a constitution is the procedural framework which it provides for allocating resources. In the United States, various governmental institutions make alloca-

tions involving telecommunications. The procedures which these institutions use depend on the constitution or statutory law, and they vary depending on the issue (or resource) and the circumstances (or politics) of the allocation.

The institutions and arenas discussed here should be viewed as alternatives among which most interested parties can choose. That is, each arena is charged with making various kinds of policy determination, and an interest which is unsuccessful or noninfluential in one arena can seek redress in another. As the book will outline, each institution cannot do the same thing or make the same decision, but each can provide some opportunity for allocation. Many of the actors involved in telecommunications policy-making value the alternative arenas available and use them when they feel they can obtain a favorable decision from any one of them. In addition, the kinds of policies vary from arena to arena. Thus, a formulation by Congress will take a different form and have different consequences than a court decision or a decision by the FCC.

Regulatory Agencies

Agencies of the government which are not mentioned in the Constitution perform the primary allocation functions relating to the field of telecommunications. The Federal Communications Commission, the Interdepartmental Radio Advisory Committee, and the Office of Telecommunications Policy all play different, but important, roles in the political process, yet none of these have constitutional status.(2,3,4) They have been created by act of Congress or by executive order, and they have legal or advisory authority which place them in central positions with regard to allocation.

The major regulatory arena in telecommunications is the FCC which has been given statutory

authority to regulate interstate wire and radio broadcast operations by private companies in this country.(5) Since 1934, when it was created, the Commission has issued general rules governing the conduct of business by common carriers, such as interstate telephone companies, and by broadcasters, such as AM and FM radio and television stations.(6) In addition, the FCC regulates the use of the spectrum by individuals or companies who seek enjoyment or profit through communications. These include mobile radio users, such as airlines and maritime companies, and citizens operating shortwave broadcast stations. The primary focus of this book is on the major commercial users of radio spectrum, such as broadcasters, and on the wire common carriers. Additional details about FCC authority are contained in the Appendix where portions of the Communications Act of 1934 are presented.

The major segments of the industry which the FCC regulates involve large companies with vast resources of money and technology. The regulation of these directly influences the development and utilization of technology. Many observers have charged, however, that the FCC has been "captured" and is controlled by the clientele which it is supposed to regulate so that its allocative decisions reflect those interests rather than the interests of the general public.(7,8) The statutory guidance for the agency is that it is to regulate in "the public...interest."(9) However, this vague phrase has no precise definition and gives the agency wide discretion to make whatever decisions it wishes. Since there has never been a precise definition of the public interest, the usual approach is to define the public interest in terms of whatever considerations and interests one wishes. Under this guidance, either the public interest is what a particular company wants if it is the only party involved in the agency proceed-

ing, or it can be a mixture of all the interests or forces involved in the allocation process for a particular policy issue, including competitors, citizens groups, and others.

Generally, the agency has tried to balance various competing interests on an issue before reaching a decision. This may be nearly a superhuman task since some of these enterprises may be diametrically opposed to others or the variety of them may be great. It is interesting to note that even if the FCC has repeatedly sought to balance these interests and not injure any one of them greatly, the agency has most frequently not injured the vested interests of the clientele it regulates. Except in recent years (which may be the exception to the rule) the agency has never made decisions which consciously conflict with the interests of established common carriers or broadcasters. Despite isolated decisions which result in some disadvantage to a particular member of the regulated clientele, the agency's general policies tend to reflect this effort at compromising and protecting the clientele.(4)

Whether the agency should balance interests differently than it has, is an engaging and important policy question. The answer depends largely on the policy the individual observer prefers. It is important to observe that the agency is a central arena for the allocation of resources in the telecommunications industry. It is the arena where most of the interests focus most of their efforts. Although lobbying is not a precise term, these groups do devote much of their lobbying efforts to the agency and its personnel. There is a nexus between industry jobs and agency jobs, and the transfer of people between the agency and the industry tells an important part of the regulatory story because high-level personnel do transfer easily and frequently from one to the other.(7)

Furthermore, the regulated interests do petition the agency for various policy decisions at various times. This direct petitioning is not lobbying but rather direct requests of the agency to exercise its allocation functions. The agency, using various procedures, considers these requests and usually acts upon them. Despite charges of delay and procrastination, the FCC's decisions usually respond in some fashion to the demands made upon it. Often these responses acquiesce in a vested interest's requests or deny a challenger's petition.

The Legislature

The legislative body, the U.S. Congress, is involved in telecommunications allocations in various ways. Obviously the enactment of a statute requires a good deal of Congressional action and effort by many people. However, in less direct ways, Congress fosters allocations, controls them, or makes suggestions. Through a statute, Congress can specify which industries will be regulated and by what means. In rare instances the legislature can make an allocation itself, outlining which procedures and which interests will receive what resources.

Congressional procedures are complex and are often cumbersome and slow. The complexity of most modern legislation requires that the Congress specialize by subject matter. Thus, various committees perform the primary functions of screening proposed legislation on topics such as telecommunications.(10,11) These committees, composed of selected members of Congress, may review agency decisions, may hold hearings on proposed legislation, and may repeatedly review the budget proposals of the agencies. Thus, through such legislative oversight, Congress exerts pressure on agency allocation processes.(12) Although Congress

monitors what agencies do through budget hearings and annual reviews and is thus in a position to make necessary adjustments, it does not meddle in the allocation process in most circumstances. The agency may respond closely to the suggestions Congressional committee members make, since the life blood of the agency, its budget, must be approved by these committee members.

On rare occasions, Congress may become so concerned about a particular policy that it will proceed beyond the oversight function. Thus, the appropriate committees might seriously consider proposed legislation with an eye toward changing the situation Congress is concerned about. Some examples of this in the telecommunication field will be discussed in later chapters. However, remember that enacting legislation is the extreme form of Congressional activity, and it is actually the rare case. The legislative process is quite slow and is filled with many obstacles which substantially reduce the likelihood of enacting legislation. Only if a proposal is strongly supported by the White House, a large group of Congressmen, the private lobbies, or some combination of these is a proposal likely to reach any stage beyond being introduced and referred to committee. With various coalitions of support, however, a bill may be enacted. This is a relatively clear legislative pronouncement of purpose and policy preference. Most legislation tends to be general and sometimes is unclear, so that interpretation of policy must occur by the executive, by the agencies applying a statute, or by the courts which may be called upon to interpret the meaning of the statute. However, any Congressional statement of policy in the form of a law is more formal and precise than many other political influences which operate on policy matters.

The political forces which operate on Congress are much more numerous than those the FCC feels.

The same interests which lobby before the FCC also lobby before Congress. However, in the legislative arena they are much less the center of the process since their interests do not necessarily have great weight with Congress, and many other interests compete for Congressional attention. Various telecommunications lobbies do surface and do become very active when legislation is being considered which will impact on their interests. Interests have attempted to achieve legislative action on a policy when the FCC has decided against the interest, and the FCC has lobbied for some legislation at times.(4) The congressional-agency relationship is largely in terms of the oversight function mentioned above. However, there are clear cases in which the relationship is the more traditional legislative, lawmaking function. Some of these efforts are illustrated in the following chapters.

The Executive Branch

The role of the chief executive in telecommunications politics is not unlike the role played in other policy areas. The President, as head of the Executive Branch, relies on staffs to assist him through policy suggestions, proposed legislation, analysis, and administration regarding the subject matter area.(13) The President cannot possibly devote any major portion of his time and decision making to a particular policy area, and only when a problem arises, a large and vociferous interest surfaces, or some apparent need for action occurs, does the President become directly involved in such policy making.

Beyond the President, however, there is a bureaucracy within the Executive Branch which specializes on the telecommunications industry and devotes full time to considering issues arising in the area. The structure of the staff varies with each President, however. The Office of Tele-

communications Policy (OTP), and the Office of Emergency Planning have been recently structured to serve the President as advisers on the subject and as analysts of policy proposals.(14) These arms of the President can be very effective in reaching policy agreements with industrial concerns, proposing legislation, and developing budget proposals for the implementation of such policies.(15)

In traditional terms, the Executive Branch is intended to administer policies, and in these terms the appropriate cabinet members may use staffs of expert assistants to work on communications problems which relate to each department's operations. Thus, the Department of Defense requires a large group of communications advisers to deal with problems of national security and military command relating to communications systems. The Department of State must deal with various problems of communications relating to international relations and our conduct of foreign policy. The Departments of Commerce, Transportation, Housing and Urban Development, and Justice all have groups which consider and work on problems of communications which relate to the missions of these departments.

One of the major communications functions of the Executive Branch is in the role of policy formulation. This involves the President in the formulation and suggestion of major policies in all areas of government concern including communications. The executive has become the major initiator of legislation, and, as a result, the furtherance of a telecommunications policy through enactment of a law is likely to require White House approval if not active support. Through the executive functions of budget control and planning, the White House has become central to the initiation, as well as the administration, of policies.

The result of this is that the White House is subject to various kinds of political lobbying.

While the lobbying efforts relating to the White House are different than legislative lobbying tactics, the same advocates and participants may be involved. The access patterns for interests differ and that explains much of the difference with regard to White House lobbying. An interest's access to the White House is much more closely tied to the preference of the President (the individual), than in Congress, where nearly any interest can probably find one or more sympathetic legislators out of 535. Thus, the arena chosen for lobbying depends on where the interest has the best access, and the White House is one of a number of arenas which give opportunity to various telecommunications interests on occasion.

Beyond the relatively formal functions of initiating and administering legislation, the Executive Branch provides opportunities for political compromise and settlement among various contending interests. The President and his staff perform the role of mediator and broker.(15) Just as Congress plays a major role in controlling agency policy through oversight, so the executive can formulate and get agreements among interests by talking with them and getting them to talk to each other. While the President may be able to influence the decisions of administrative agencies, the regulatory agencies are supposed to be independent of partisan political influence. The President, once he has appointed the members of the Commission, may have little access to the agency's decisions. However, in its own right, the power of the Executive Branch places it in a central position to advocate positions, suggest compromises, and, in some cases, dictate results, when there are major policy differences among factions or groups of interests.(14) As some of the following cases will illustrate, this informal brokerage may be the most important role performed by the executive in terms of policy formulation and operation.

The Judiciary

While in formal, constitutional theory the judiciary is not intended to make policy, the courts in this country do perform policy making functions by interpreting statutes and by deciding other cases involving the law.(16,17) Given a factual situation, the court can be presented with significant policy questions (phrased in terms of legal questions) which impact directly on developments in the telecommunication field. Some examples of this include the Supreme Court's decision giving the FCC jurisdiction to regulate cable TV as an ancillary to the wire and broadcast regulation given the commission by the statute. Others are repeated court decisions, that, under the then existing copyright laws, cable TV companies are not required to pay copyright fees to the holders of the copyright privileges for television programs carried by the cable.(18,19)

Although the courts are not directly subject to political lobbying as is Congress, the President, and the FCC, the judiciary can be a selected political arena in which an interest will seek to vindicate its position or achieve a policy outcome.(20) An interest can litigate a case, in order to gain an advantage over a competitor, rather than lobby Congress for the enactment of a statute. While the primary examples of judicial lobbying are found in civil rights litigation involving minority interests which could not get a satisfactory hearing before Congress or the other branches, communications interests which lose in the agency or Congress, can and do "appeal" to the court for reversal of the adverse decision. The examples discussed later in this book illustrate some of these efforts, and in a few instances their success.

While most people may not consider the court as a viable arena for policy making, the only requirements for getting judicial treatment of an issue

is to develop a "case" which involves a legal question. Thus, any set of facts which can present a legal dispute between two parties can be taken to court for a resolution. Lawyers are trained in framing legal issues, and nearly any major policy question in communications policy (in any subject matter for that matter) can probably produce at least one legal question. Whether the party will want to litigate the question depends on the amount of time, money, and interest in the question and on the likelihood of winning in the court. However, it is quite possible to construct such a case legitimately in order to seek a favorable policy result which could not be obtained in the other political arenas.

Political Actors

From this discussion, we can see that many different interests and policy positions appear in the telecommunications area. The actors generally tend to have a stake in the outcome of governmental decisions. They seek favorable decisions by many different means, some legitimate and some possibly illegitimate. They are not always consistent, they may conflict directly with one another, or they may overlap on some matters and form strong, momentary political coalitions. This is clearly the general proposition of politics--the competition of various interests for the allocation of scarce resources. However, the examples provided in this book will involve a relatively small number of interests. The actors will become familiar to the reader, even if their positions are not always the same or even always clear. It may not be necessary to provide much more here than a listing which the reader can use like a score card. However, it is important to describe, in general and specific terms, the kinds of interests which

appear and the kinds of tactics they employ to achieve their desired ends.

Generally, interests in this area do not contend in the political arena for technological decisions. That is, they do not advocate the choice of technologies which the government then settles on as *the* appropriate means for processing certain communications. Such technology allocations may occasionally arise as in the case of competing systems of color TV in the early 1950's, but they are infrequent. Largely, the interests compete in the political arenas for economic advantages over competitors. The kinds of issues which arise often tend to be basic economic ones, and the tactics of the participants tend to be direct, obvious, and frequently strong because the stakes are significant for them, if not for all of society.

The kinds of interests which surface in this area are not unlike those in other areas. The most active and successful ones tend to be those which have a clear position and policy preference and which are directly concerned and affected by the policy. Recently, more diffuse interest groups have surfaced which appear to have sufficient strength and political resources to compete in the political arenas. Consumer groups and groups of users or viewers of telecommunications services are many in number, difficult to organize, and so diverse in interest that it is unlikely they will be able to pursue a consistent policy effort through lobbying. If they could, however, they would probably be a strong political force because there are so many of them. Policy makers tend to listen to large numbers of voters, because their continued political careers depend on being re-elected, so consumers could exert great pressures on elected officials, even if not on appointed agency members. Only in a few policy areas have such diffuse groups voiced much interest, and that has occurred only in recent years.

It should be apparent that the kinds of interests involved are large groups of diffuse membership with only minimal or tangential and passing interest in an issue. In contrast to these kinds of orientations, a smaller group of companies is involved in the communications industry and is directly and immediately affected by any policy made in the area. These tend to be constantly active or on watch and they appear at every opportunity to deal with a policy consideration which concerns them. These groups include the common carriers and broadcasters who are themselves regulated by the FCC and who compose the immediate, communications industry. In addition, peripheral interests involve equipment manufacturers and specialized users of portions of the spectrum who lobby constantly and sometimes successfully for policies which favor their interests.

The Vested Interests

Under this category any company which had a stake in the status quo would be included. Thus, the vested interest in any particular situation depends on what the issues are and who has become established in providing the service. Generally, the most prominent vested interests include AT&T which has all the long distance, and much of the local voice telephone communication market in this country. The company also is the principal international voice carrier, and a subsidiary of AT&T (Western Electric) is the major developer and producer of telephonic equipment in the world. In addition, the Bell Laboratories are a part of AT&T and constitute the world's leading, private research and development organization in the communications field. Other established common carriers include non-Bell telephone companies, Western Union which provides much of the record (non-voice) communication service in the country, and

such international carriers as ITT and RCA. Among broadcasters, the established interests include the networks and the licensed radio and television broadcasters.

While this group of interests may not seem to be particularly large, remember that they form the backbone of the communications industry in this country and possess enormous resources for lobbying in political arenas. They also have a large number of economic and technical interests which give rise to many and frequent efforts at obtaining protection and favorable treatment from the political actors. The broadcasting interests may illustrate this point since they operate on the basis of licenses issued by FCC assignment. Their interests in these licenses are great since the investment in broadcast equipment is great, and their revenue from the sale of advertising time suggests the amount of income they can expect from the possession of the license. As a result of the investment and the value of the license, broadcasters make major efforts to deal with threats or challenges to the status quo. Some changes may benefit them, such as current legislative proposals which would extend the license period from three to five years. However, the broadcasters, just as most other established interests, are more on guard for threats to their position than making efforts to improve it.

Interestingly, the established interest in any specific instance will depend on who is defending the status quo. As a company becomes protected or has something which it seeks to protect, it becomes a vested interest in communications politics. Thus, over time, if a new competitor is successful in gaining entry to the market and succeeds in making a profit, that company will become a political, vested interest which lobbies for the status quo or continued protection of its position. Political and policy change will produce new estab-

lished interests seeking political protection or continued advantage in the communications field.

The New Entrants

The other major set of identifiable interests is comprised of the challengers who seek some changes in the status quo. These are usually companies which propose to offer a new service or provide an existing service at competitive rates. These are generally companies seeking to be permitted to compete with the vested interests. Examples are outlined in subsequent chapters, which indicate the reaction of established interests to such threats. In recent years, the FCC seems to be allowing some new entrants into arenas previously monopolized by the established carriers. For many years, the FCC, as most other federal regulatory agencies, made few decisions that disturbed the established interests. Either because of cooperation by the industry, or because the commissioners felt that the established interest could best perform their obligations without competition, the commission, until the mid 1960's, made no decisions which did anything but reject the various efforts of the challengers to enter an established market.(21)

Protection of the industry has been a major political issue for many years, and there are examples in which the courts, generally viewed as very conservative bodies, reversed commission decisions protecting the industry and required the agency to permit entry of new companies or permit some action which the industry argued would injure their position.(22) The political efforts of potential entrants depends on the amount of resources they have for lobbying and on the policy climate in which they find themselves. Thus, recently, new entrants have been receiving favor-

able decisions from the FCC itself, while in previous decades a challenger had to persevere beyond the agency--into the courts, legislature, or executive--in order to succeed. The recent political efforts of these interests have required less money and time and have resulted in more successes because of policy orientation changes in the agency.

Beside new entrants, other challengers may be groups of users. While we all use the telephones, watch television, and listen to the radio, we rarely would consider seeking some sort of allocation from the FCC. In recent years, however, the users have begun to intervene frequently and with some success in agency license renewal cases. Some would claim that the commission's statutory objective of regulating in the "public interest" means that the commission will, on its own, consider such user interests and the users themselves have little need to appear. However, with the rise in consumerism and various public interest groups in recent years, other observers would claim that the agency ignores such interests unless they are presented in the proceeding in the same fashion as the requests of the established interests or the challengers.

There are other users besides the listeners and watchers. Some companies use a large amount of communication service on a continual basis. Thus, a large company, with plants throughout the country, may lease a telephone line from AT&T which is permanently dedicated to linking all the company's plants. These large users form a significant portion of the common carrier market, and as large, continuing customers, the common carriers usually seek to provide quality service to them. There have been occasions when the commission's decisions have been adverse to the carriers and to large users of services, and in one particular

case the users, rather than the carrier, sought a court decision which would protect the carrier's position.(23) This same category of users can provide the basis for new entrants to seek licenses to offer services. If the established carriers are not providing a service or are doing so at higher rates than a new entrant, the users who would "switch" to the new entrant provide market support for its claim of entry and provide the obvious economic base upon which the challenger seeks to make a profit. These users may be mobilized for political action by the challenger to support their petitions.

Another large group of "challengers" may more properly be viewed as both vested interests and challengers. These are equipment manufacturers and developers who profit by the use of various kinds of technology. These groups can benefit greatly from various decisions which require the offering of certain services, since this decision creates the market for the devices produced by these companies. The manufacturers of mobile radio telephone equipment, for example, have been at the forefront of efforts to get the FCC to allocate to mobile communications increasingly larger portions of the radio spectrum. So have producers of citizens band communications equipment in recent years. There are other examples of these efforts by manufacturers which are illustrated by some of the cases examined in subsequent chapters.

Note that these equipment manufacturers, just as some established interests, have another set of interests in the political arena. These companies often make a good portion of their income from sales of equipment to the government. The Department of Defense and other cabinet agencies *use* telecommunications equipment and services and they do not make it themselves. Government contracts are a lucrative source of business, and, for these

manufacturers, such contracts often supply a major impetus for their research and development of new technological devices. For example, the use of geosynchronous communications satellites was made possible much earlier than expected because of government contracting with a manufacturer to develop such a working system (contrary to the technological development and position of the other private organizations developing communications satellites in the early 1960's).

One last group of challengers has appeared occasionally in communications policy issues. This group is composed of independent research organizations or nonprofit foundations which have some interest in the development of communications policies or investigate such a subject because there is some "public interest" concern which the organization seeks to represent. This group includes such organizations as the Ford Foundation, the Alfred P. Sloan Foundation, and the Committee for Economic Development. Some universities, such as Harvard, have developed programs which do research work for the government or other supporters which seek policy impact. Only isolated examples of these kinds of interests surface in the cases this book presents. However, they have played roles in several of the cases. Either because they are prestigious organizations, their policy recommendations are persuasive, or their position is close to the compromise position settled on by the policy maker, these groups can appear to have substantial influence. Rarely will such a group begin with a preconceived policy preference. Some of them shun policy choices, but present only their "analysis" of the issue. However, some do present policy recommendations at the conclusions of their investigation.

Public Officials

The last set of actors which is central to the political allocation process is the persons in public positions who have the obligations and duty to make authoritative decisions. These are the arena occupants and, in some sense, they are the arenas, since institutions without people are meaningless. Some of these officials are elected and are "obligated" to represent a particular group of constituents. Congressmen represent either a state (in the case of U.S. senators) or some sector of the state (U.S. representatives). The President represents the entire nation. The degree to which any of these constituencies can be represented by a single person is questionable. However, as a result there is a heterogeneous set of representations made in the decision making arenas, by the decision makers themselves as well as by competing lobbying interests.

It may be impossible for an individual to determine the interests of a constituency, let alone to represent them effectively in a political body. Any geographic region which is represented in Congress has a multiplicity of interests, many conflicting and some overlapping. This makes it more impossible for the elected official to present a clear, accurate view of his constituent's interests. Some representatives do not try to reflect their constituents' views but simply use their own ideas and values as guides for decisions. Other decision makers try to reflect constituents' views on some issues, but on other matters use their own judgment or follow what they think is the "public interest."

Besides elected representatives, some decision makers are appointed and thus are not responsible to an electoral constituency. These appointees (largely agency members and federal judges) are not objective automotons but have preferences and biases just as other people. However, they may be

less restricted in exercising those biases than are the elected decision makers. While Federal Communications Commissioners and judges undoubtedly feel that their roles require that they weigh and balance a large variety of competing interests, and they probably try to do this conscientiously, they still may be less representative than elected officials. To whom does a judge, appointed for life, have to answer? No one specifically, even if the judge feels largely constrained to do a conscientious job of "judging" objectively.

Appointed by the President, FCC members serve for seven-year terms, and the statute requires that the members of the commission must be balanced to include no more than four members of any one political party.(24) This last provision is designed to protect against a completely partisan commission. Many observers have charged that the agency's constituency may not elect them but they are likely to be employed by the constituency (the communications industry) after their seven-year term expires.(7) There has been a good deal of interchange of personnel between the Commission and the industry, and the decisions of the agency *may* generally reflect a pro-industry bias. However, these kinds of considerations are probably not too important if the overall picture is considered.

The variety of officials who can and do make decisions concerning communications policies is great. There may be wisdom in this because it permits a wide set of interests to have some "representation" in the decision-making process. The resulting balancing of interests and various checks on decision makers do not result in policies which are likely to injure one particular segment of society repeatedly. Since competing interests have a variety of arenas in which to seek resolutions favorable to them, and since many interests have representatives among the policy makers, it may appear that the political process is designed to produce policies which balance competing interests.

International Politics

While most of the discussion presented in this book involves domestic telecommunications policy and domestic politics, international politics and considerations are also of great importance. In fact, international cooperation and diplomacy are directly involved with many of the same questions which will be discussed. International forces arise because much communication itself is international in character. This requires arrangements for such transmissions. In addition, the radio spectrum and problems of its allocation for various users and uses involve international issues since radio interference does not stop at the national boundary of a nation. Thus, there is continuing and growing need to coordinate and schedule various uses among nationals in order to reduce interference to an acceptable level. Furthermore, some technological development and utilization involve international uses and adoption. Such technological developments rely directly on international diplomacy.

Several basic points about the international dimension should be made at the outset. First, much of the international interaction involving problems of telecommunications is based on the pursuit of national goals of foreign policy. Various states seek allocations and other agreements which benefit their own users or their own uses. However, in apparent contradiction to this statement, there are many examples in which the participants seek to reach mutual accommodations for the use of spectrum or facilities. Thus, there is an element of tolerance and accommodation among national users of telecommunications facilities so that all comers may receive some benefit. In addition, there are certain elements of squatter's rights in spectrum allocations. This unwritten rule of registration of spectrum uses--the first come, first served

principle--is evident in various, competing claims for the use of spectrum. Lastly, it is possible to use the airwaves and other telecommunications systems for political propaganda purposes. These political objectives might be rejected or opposed by various groups of users, but it is likely that technology will be developed and used for such purposes.

International Institutions

Over the years ad hoc, international bodies have been developed for dealing with specific telecommunications problems. However, these are creatures for an immediate problem and usually do not last beyond the problem which gave them impetus. Also, there are permanent bodies such as the International Telecommunication Union (ITU), a special, permanent United Nations agency which deals on a continuing basis with various international communications problems. The ITU provides the central body for clearance and registration of spectrum-use requests made by member nations. The United Nations itself has been dealing with some telecommunications issues on a continual basis through its ad hoc Committee on the Peaceful Uses of Outer Space. This body prepares studies and makes general policy recommendations, such as communications satellites, which relate to international uses of space.

As an example of a permanent international body in this field, the International Frequency Registration Board (IFRB) is a special agency within the ITU which handles the registration of spectrum uses by nations.(25) Although the uses to which nations put the spectrum are supposedly noninterfering, and the IFRB supposedly does have enforcement authority, the general rule of operation for the board is to accept any registration on a first come, first served basis, with little enforcement of regulations regarding usage. Some would argue

that such an ineffective policing body serves no purpose and should be abolished. However, the mere function of registration is important, because it provides a central clearing mechanism for recording uses and allocations. The utility of this depends on the objectives a nation is pursuing, and the effect of the process on the achievement of those goals. A nation is likely to support the IFRB process if that country has been able to secure registration of its uses first, and thus enjoy some protection by the IFRB. Another nation, a late comer in registration, may oppose the process because it has been frozen out of a particular portion of the spectrum.

In addition to the IFRB, the ITU has two other units which deal with telecommunications problems at the international level: the Consultative Committee on International Radio (CCIR) and the Consultative Committee on International Telegraphy and Telephony (CCITT). The CCIR is concerned with standards for various aspects of long distance radio communications. This function overlaps the IFRB, except that the IFRB deals primarily with the problems of radio interference and registration, while the CCIR focuses on other standardization matters. The CCITT devotes its time largely to making studies and recommendations on a wide number of aspects of telephony and telegraphy. This organization uses study groups to reach various conclusions and standardization recommendations on a vast array of telecommunications topics such as switching, signaling, noise, transmission, and performance.

These three bodies illustrate the value of international cooperation and its tentativeness. Many more problems would arise in international communication if it were not for these clearing agencies. However, their success depends on the willingness of members to cooperate and accept various policies. Usually, the bodies will not

make a recommendation without careful study and widespread support from participants. This insures the adoption of the recommendation and the continued success of the body. These bodies deal with matters about which there may be little, heated political conflict, and this increases their viability. On the less widely accepted ad hoc issues, such as the INTELSAT arrangements and operations, national competition still arises, and may interfere with the technology and its utilization.

INTELSAT is another international body which directly relates to an important area of international telecommunications. Recently reformulated as a permanent body with operating procedures, INTELSAT is the collection of nations which jointly own and operate the international communications satellite system developed since the 1962 creation of the United States Company, Communications Satellite Corporation (COMSAT).(26) The creation and operation of INTELSAT is an interesting example of the mixture of national and international politics. Most importantly, it indicates the roles of technologically dependent and independent countries in terms of international cooperation. Given the technological superiority of the United States in communications satellite development since 1958, this country pursued a set of goals for the development and utilization, as well as control, of such a particular communications system. The technological dependent countries of Western Europe were in a weak bargaining position during the early phases of INTELSAT's operation. Only in the negotiations for the permanent arrangements of INTELSAT, during the 1969 to 1972 period, did these countries exert some significant pressure that adjusted the arrangement for operation of the agency and procurement of the satellite technology.

INTELSAT, both the temporary and the permanent structure, illustrates a number of policy preferences. Various participants sought to foster their own objectives or obtain various benefits from the arrangement. Whether each country achieved what it wanted or is satisfied with the outcome is another question. It is important to consider that the development of this particular technology and its use for international communication depends upon international politics and various foreign policies which may be at odds with one another.

The International Actors

Certainly the most prominent actors at this level are the nations which have some interest or economic stake in international communications. Some nations are users only, while others not only use the service but also provide the technology that makes these communications systems possible. While it is not always possible to discuss a *national* interest, since there may be competing interests within a country, one can view the state or official governmental representative as the primary actor in the international arenas. Thus, the foreign policy objectives of individual countries may become important aspects of international telecommunications matters, just as the technology is only one part of the domestic technology development of telecommunications. The conflicting national objectives which arise are interesting, and they tell a good deal about what agreements and other results appear from international negotiations.

Among the countries which operate in the international setting, an important distinction can be made between those which have the technology and seek to "export" it, and those which are technologically "poor" and are recipients of the technology. There are interesting cases in which the exporting nation has made major, overt efforts to

pursue various policies which benefit it, while imposing costs and other limitations on the target countries. Generally, the advanced countries have the technological capability to export devices and services, while the developing countries tend to be the target, users of various devices. Only the United States and Russia were in the position of exporting satellite communications during the mid-1960's and, as a result, could nearly dictate the terms under which they provided the service and the technology. Although some European countries have worked vigorously on developing an independent technological base for such services, they are limited by the difficulty in launching communications satellites without an active space program. Some European countries have even united in an effort to develop an independent launch capability as well as communications satellite ability. Their efforts have enjoyed only limited success to date, facing a good deal of political and economic opposition from the established exporter (the United States).(26)

The developing countries or any recipient country may not readily accept a technology or a service which is being exported to them. The independent/dependent relationship of these countries tends to make them suspicious and often antagonistic to proposals from a dominant country. Even if an important, revolutionary technology would greatly facilitate various kinds of international communications, its utilization may be hampered or even blocked by national jealousies and competition.

In addition to the national actors, some users of technology and communications channels are vitally concerned with international policies regarding these areas. Thus, the international carriers who provide international links for voice and record communications are centrally interested in the policies operating among countries or with-

in international organizations which affect them. In addition, the individual who uses international communications channels may be affected by these policies. However, rarely are individuals capable of having much impact on such international policies. Beyond the benefit of reduced rates for international communications, these individual users have little direct concern.

What this means is that even on the international level, possibly even more so there than at the domestic level, the adoption and use of technologies may be hindered by nontechnical factors. The competition between cultures and political beliefs may increase the problems of technological adoption. The competition among nations for prestige and other nonmaterial benefits, as well as the real competition in terms of economics and political objectives, may shape the development and use of technology.

A General Model

Figure 3-1 diagrams the kinds of relationships which can exist in the domestic political process, with particular reference to the telecommunications industry. It shows the actors who most frequently appear in the process, the arenas in which the decisions are made, and the potential interactions between the interests and the arenas. It is interesting to note that this general model has outlined all the possible combinations of interests and institutions. In this form, the model is not very helpful to the observer who is interested in the particular relationships for a specific policy decision. This model, throughout the discussions of case studies which follow in subsequent chapters, will delineate interests and arenas in each particular decision and show the relationships which existed in that case. In that form, the model will summarize the allocation process as it occurred in

each case. The various lines, specified in the key to Figure 3-1, will be used in later figures to indicate the strength and direction of various relationships in the particular policy area being analyzed.

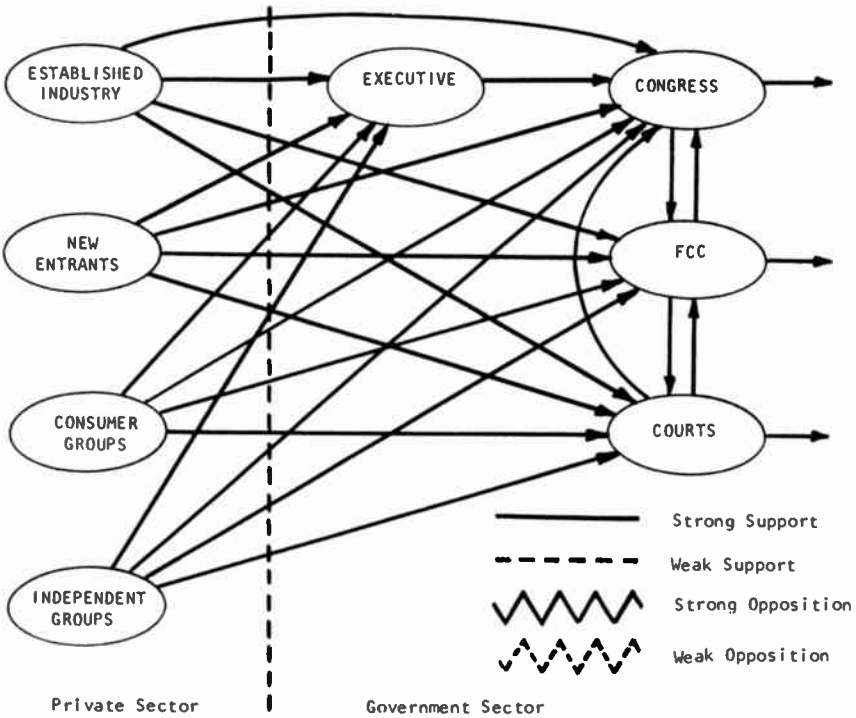

Figure 3-1 General technopolitical allocation model

It is difficult to present causal relationships for any case since "causation" in the social sciences is difficult to establish. However, the models which follow for the cases are qualitative evaluations of the actors and arenas and results which appear to have been controlling. Hopefully, future investigations of these and other policy examples will result in more precise and certain statements about causation.

Several points can be made about the policy results of this model and discussion.

First, most policies are not likely to break drastically with established policy patterns.(27) Rather, any new policy probably will be an incremental change from the status quo. The balancing of established and challenging interests and their relative strengths in political arenas suggests that changes will be minimal and less frequent than the nondecisions which leave situations as they were.

Second, the continual introduction of new technologies and new potential entrants suggests that in communications there will be frequent and repeated opportunities for policy changes. Some challengers will always be able and willing to compete if given the opportunity, and they will seek that opportunity. Thus, the policy-making system will be busy processing such demands and contending with the competing political forces. The result is likely to be gradual, but frequent, adjustments in policy. Only if the established interests completely control one or more arenas, will there be a major and lengthy blockage of policy changes. The cases which follow include some successful challenges in recent years.

Last, rarely are any final decisions reached in a policy area. There are temporary or momentary results upon which the actors then proceed to develop technologies and provide services. However, most policy decisions are open to subsequent revision, as actors or forces lose or gain strength in various political arenas. Thus, the cases explored in this book indicate temporary resolutions of policy questions, and in some cases these have been modified or reversed since the time of the decision. The lack of final results indicates that public policies are never fixed, and resource allocation by these processes involves a continual, ongoing contending of various interests, rather

than final outcomes of the competition among interests.

The Economics of Telecommunications

There are two major parts of the telecommunications industry, and these are treated separately in chapters to follow. The broadcasting industry utilizes a particular set of technologies in order to reach the largest possible audience, while the common carrier industry provides services to any user on an individual use and cost basis. These two kinds of services are reflected in various economic considerations, and they structure the use of technology and the services which are available to whatever kind of user.

The economic considerations discussed here are intended to provide a general perspective which will be developed in more detail later, when discussing particular decisions. However, it should be apparent that the economics of telecommunications do not operate with theoretically perfect efficiency. Rather, market imperfections, government intervention and allocation, and various political constraints add to the "economic" considerations a substantial amount of imperfection and a need for various kinds of artificial structures on the economic functioning of the industries involved. Our discussion is divided into the two separate areas of telecommunications since some of the characteristics of each are unique. It is designed to provide an appreciation of the general features of the economic setting of telecommunications.

Broadcasting Industry

The structure of this industry is based on broadcasting a single program from a single source to as large an audience as can be attracted. In this type of commercial venture the amount of revenue

a broadcaster receives from an advertiser is based on the size of the viewing or listening audience the broadcast reaches. In turn, the size of the audience depends on the attractiveness of the program being broadcast. So, it is to the advantage of the broadcaster to present programming which will attract as large a commercial audience as possible. The revenue from such broadcasting is derived from commercial advertisers who "buy" advertising time to sponsor the program, depending on the size of the audience and the time of day during which the program is aired.(28)

The logical conclusion of this structural feature would be a single program which would attract all the viewers. However, this extreme has not materialized, although many critics of present-day broadcasting complain about the dearth of program diversity. In addition to this program concentration feature, based on attracting commercial viewing audiences, the costs of program distribution have led to the development of networks which offer a complete set of programs to affiliate stations in an effort to: (1) reduce the difficulty of obtaining large, nationwide audiences for advertising purposes; (2) centralize the acquisition of high-quality and entertaining programs from a diverse set of program producers; and (3) make the local broadcaster's need for program production minimal. The networks do not produce programs but rather purchase these from program producers, which include the Hollywood movie companies among others. Then the networks offer the individual broadcasting affiliates the option of a complete package of programs.

The centralizing tendency of the advertising and the programming features of broadcasting conflict with a basic policy followed for decades by the FCC. The commission has operated with the objective of providing a locality (the smallest possible audience segment) with at least one local source

of programming. That means that the FCC seeks to foster the development and operation of local broadcasters (local radio and television stations) under the assumption that such local operation will provide the citizens with local programming and other features which are of local, rather than national, interest. Thus, the allocation of the broadcasting spectrum among broadcasters is based upon this policy assumption and objective, and is in conflict with the actual economics of commercial broadcasting.

The basic reason for licensing of broadcasters is the scarcity of usable spectrum for these purposes and the early congestion which resulted from overuse of the spectrum by broadcasters in the 1920's.(29) This policy will be discussed in greater detail in Chapter 4. It should be apparent, however, that the need to allocate the scarce resource of electromagnetic spectrum on the basis of some policy--in this case, localism--has produced a countervailing, if not successful, balance to the centralizing tendencies of program production and commercial audience needs. Whether the broadcast industry would operate in the same economic fashion if the policy of localism did not exist is an open question. It appears that the strong pressures of the network and the commercial advertising objective of mass audiences, rather than isolated, local audiences, would only be more pronounced than they are at this point, if the regulator were following a nonlocal licensing policy.

Licensing is the FCC's major power over the broadcasting industry. The requirements that the license be renewed every three years, that no broadcaster can trade in licenses (trafficking) and that no broadcaster obtains a property right in the license clearly is designed to indicate that the "airwaves belong to the people" and they are being loaned, with no charge to the broadcaster, for use in the "public interest." Regardless of this

statutory view of the license to broadcast, the broadcasters do sell stations for much more than their market value, and this additional revenue is often seen as the value of the license that goes along with the equipment and the building.(30) This is especially true of broadcasting stations in large viewing areas--large cities or metropolitan areas--since these stations reach large commercial markets and thus generate substantial advertising revenues to the station owner.

In this economic situation, there is no guarantee that the market--commercial advertising to mass audiences--provides any clear indication of program quality or approval as a measure of the public interest. Some observers have suggested that a system, such as subscription or Pay TV, which permits the viewer to "vote" for programs by directly paying for them would be more economically efficient. This policy area is developing and will be discussed in more detail in later chapters. However, if such direct payment for programs were allowed, the "middle man"--networks, and commercial advertisers--would be eliminated. Broadcasters and viewers would have to bid for attractive programs with the program producers. A large portion of the existing broadcasting industry opposes this kind of mechanism because of the possible and profound ramifications it would have for economic status quo.

Common Carriers

There are two justifications for regulating common carriers by a governmental agency such as the FCC.

The first is identical to the regulation of broadcasting--the need to allocate the scarce electromagnetic spectrum. The frequencies and other technical constraints involved in common carrier use of the spectrum require close supervision and regulation.

The second reason for common carrier regulations is that natural monopolies develop in this area,

largely due to economies of scale and the capital intensive nature of the industry, so that government regulation is necessary to protect the public from the abuses a monopolist (single supplier of a good) could impose on the consumer.(31)

There has been recent debate over whether such justification warrants regulation. For example, as technology develops, it is possible that common carriers will not have to use the electromagnetic spectrum to provide their services. Laser beams, fiber optics, and waveguides, which may be the next stages of technology in this field, do not use the radio spectrum, and they provide little potential interference with other uses of the spectrum, and thus regulation is not needed. That may not preclude government regulation, since the FCC has authority to regulate "wire" communication, but it does remove one of the justifications for such regulation.

Some observers have attacked the natural monopoly idea because it is unclear that regulation of natural monopolies produces the effects that are anticipated.(21,31) Furthermore, even the FCC has, in recent years, sought to inject certain elements of competition into the common carrier industry as a means of regulating or controlling the carriers. This will be discussed later. Whether competition will be successful in regulating or in achieving the other objectives of the policy makers remains to be seen. However, it does suggest that alternatives to the regulatory framework established and developed by the FCC for the past four decades might be viable.

The economies of scale and the capital intensive nature of common carriers do present major economic considerations to the problem of common carrier regulations.(32) It is not at all clear that any new common carrier can compete successfully with the established carriers because of the costs of building a competing system of carriers and because the

economic success of carriers depends on providing large varieties of services to large numbers of users before common carrier operation becomes profitable. Selective competition by new entrants might be successful so long as the existing carriers are not allowed to "compete" for the same business as these specialized carriers. This will be discussed in Chapters 5 and 7. However, whether this is an appropriate policy for the government to pursue and whether it will be successful in producing the kinds of results anticipated is still an open policy question.

Conclusions

This discussion has outlined some of the important political and economic factors which structure the development and use of telecommunications technologies and services. The specific political and economic considerations in any particular case will vary markedly with the details of the situation. The following chapters discuss a number of specific decisions by various government agencies and actors and illustrate the effect and impact of various of these political and economic considerations on telecommunications. That discussion should also provide a sound basis for estimating likely developments regarding current policy questions in the telecommunications industry.

Chapter 4

Broadcast Communications

Of all telecommunications services the most widely used are those of radio and television broadcasting. These services and the political arena in which they exist provide a wide range of examples of the interaction of technology, politics, and society. The major story of the development of broadcast technology is tied to the FCC's efforts to allocate spectrum and regulate broadcast communication. Several examples of policies which have been formulated to use the spectrum efficiently are explored in the following sections. They illustrate some of the political and social forces which affect the use and development of broadcast technology.

Several factors about broadcast communication, which differentiate it from other kinds, should be kept in mind.

First, broadcasting is a one-way process in which the broadcaster communicates with listeners, and the listener normally does not respond directly to the communication. At most, the listener may respond through a commercial transaction such as buying the advertised product presented as part of the broadcast message. Although recently many broadcasters have instituted talk-back programs, the basic function of broadcasting is one-way.

The second major characteristic of broadcast communication is that it is aimed at mass audiences. Instead of communicating with a particular

individual, this form of communication seeks to reach as large an audience as possible, so that the commercial messages presented will reach the largest potential market.(1) The financial success of broadcasters depends on the advertising revenue they attract. This revenue, in turn, depends upon the number of listeners or viewers who tune to a particular broadcast and thereby become targets for the commercial message. This focus has a significant impact on the shape of programming and on the economics of the industry. These matters are discussed more extensively later.

The Broadcast Spectrum

Allocation Procedures

Several factors have strongly influenced the development of radio broadcasting. Mostly, these factors relate to the nature of the electromagnetic (radio) spectrum and the process by which it is allocated. The electromagnetic spectrum provides the communication channels through which broadcast messages are disseminated in this country. The general nature and technical constraints of the spectrum are discussed in Chapter 2. One important fact about the spectrum is that it can be viewed as a "free" resource only in a limited fashion.(2) Although there is no spectrum market, and the users of the spectrum (broadcasters) acquire no property right to their assigned frequencies, the spectrum can be polluted and so overused that no user enjoys an unhampered portion of it. The spectrum can become overcrowded if too many users seek to broadcast on the same frequency or if the uses of it conflict. The basic outline which the regulators have followed to reduce such congestion is to space users geographically, by time and by frequency.(3) Thus, if two broadcasters use the same frequency but are sufficiently far apart, their use will not

interfere with each other's broadcasts. No interference occurs if the broadcasters do not use the frequency at the same time. Lastly, two broadcasters would not interfere with one another if they broadcast in different portions of the spectrum.

Most of the allocation process is focused on this need to accommodate various demands in a fashion that does not produce intolerable amounts of interference among users. The market clearing processes which would allocate the spectrum on the basis of price and which would assess the costs to the appropriate users has been replaced. A set of noneconomic processes has been established which influences the uses and the amount of spectrum occupied by a variety of broadcast users. The major costs (which must still be considered) relate largely to the political, regulatory allocation process. Thus, the way in which one insures that his uses of the spectrum are not interfered with is through political lobbying so that the allocator will not permit interference with the existing users' allocations. This political process and the accompanying costs may involve lobbying before Congress with regard to a proposed statute which would alter the allocation process or the criteria used for allocating. It may require that the broadcaster seek special or individual protection from the Executive Branch. Most frequently the allocation process for broadcasters requires the continual costs of protecting the broadcaster's vested interests in a portion of the spectrum.

The political costs of this process may be very expensive. However, this particular procedure is used because various observers and actors, including broadcasters, feel it is advantageous over the free-market process of allocation. While there is much debate about an allocation process which depends on political lobbying rather than economic criteria for success, the facts are that the FCC

has statutory authority to allocate portions of the spectrum for private users. The "public convenience, interest, or necessity" goals of this process have been left to the agency to define as it chooses.

Governmental use of the spectrum is not regulated this way, and while the government users are supposed to coordinate their use of spectrum with others, government is not constrained by any statutory requirement to accommodate other users.(4) There are examples of government interference with private users which have even resulted in government users excluding private users from certain portions of the spectrum.(5) Usually, the usage of spectrum is coordinated between government and private users, and a significant portion of the government's spectrum allocations overlaps private allocations without any great interference or conflict between the two groups. Yet the precedent has evolved of giving the government what it wants on the basis of its asking for it.(3)

Several general characteristics of the allocation system merit attention. The development of technology for broadcasting may depend largely on what uses are being made of which portions of the spectrum. That is, if there is ample bandwidth to accommodate a current use, there may be no incentive to innovate or use different technologies. But, if there is much congestion from overcrowding, one of two kinds of technological changes may occur. New technologies may be developed at the intensive margin to permit more users to occupy the existing allocation with less or no greater interference and congestion than existed before. If such innovation is not possible, the extensive margin may see an innovative effort. Thus, if there is no room in the existing band, technology may be forced to develop higher portions of the spectrum and adapt it for the original use. Both intensive and extensive margin development are well

documented, and they illustrate two technological responses to the same congestion problem.(2,3)

The initial way in which spectrum was allocated was on a first come, first served basis. As a new use arose, requiring further allocation of spectrum, the allocator simply assigned it a portion of the unoccupied spectrum, usually in the upper ranges of the then usable spectrum. Initially, this was done with little examination of the relative values of old and new uses of the frequencies. Generally, this allocation process occurred when a large amount of spectrum was unused and pressure from users was minimal. Thus, the newer entrants were assigned higher segments of the spectrum and the older established user occupied the lower portions of the spectrum. The difficulty with this procedure is that all portions of the spectrum are not equally attractive and feasible for all kinds of uses. Certain kinds of broadcasting may be done more effectively at lower frequencies, but they may be allocated a higher set of frequencies simply because their requests were made late.

This feature of the allocation process in the United States means that a de facto form of squatter's rights has developed. Under such a scheme, the first to seek often obtained permission to use a particular portion of the spectrum. Potential users who sought authorization for the same frequency carried the burden of dislodging the occupant. This situation is particularly important in terms of technological innovations. First, it causes new technological innovations to be directed toward the upper, unused, portions of the spectrum. Second, new services requiring utilization of the presently occupied portion of the spectrum also required strong political efforts as well as technological innovation.

Frequency Allocation Table

The FCC has developed a number of mechanisms and procedures to permit long-term as well as short-term (first come, first served) allocation requests. These are efforts at reserving portions of the spectrum for a particular use before a request is presented. A major means of doing this is the frequency allocation table which has been used for FM radio broadcasting and for VHF and UHF television broadcasting. The allocation table is essentially a block of frequencies reserved for particular uses. The block takes into account the amount of bandwidth required for a single broadcaster to have an interference-free operation. The block also reflects the FCC's general policy outlines about a particular industry. That is, the total amount of the spectrum devoted to a particular function will reflect how important the FCC considers the development of that spectrum use to be. Thus, the allocation for UHF television, which is quite large, reflects a major FCC emphasis on encouraging certain kinds of television development with many UHF television channels.

In fact, the allocation table may allocate large portions of the spectrum, currently empty, and it may prevent use of those frequencies, pending the emergence of the designated kinds of users. The table reflects established policies for allocation of frequency, and in that way the future allocation to users is insured by the original determination and establishment of the allocation table. A portion of the current FCC Allocation Table appears in Table 4-1. The amount of bandwidth required and the number of users determine the amount of spectrum allocated for a particular service. For example, the 70 UHF TV channels occupy a 420 MHz segment of the spectrum. In addition to bandwidth and number of users, the spectral location of segments reserved by the allocation table can strongly influence the development. Thus, moving the FM

frequencies from their original location to a higher portion of the spectrum in 1945, contributed significantly to retardation of the FM industry's development.(6)

On occasion a user has the opportunity to stockpile spectrum even though he will not use it immediately, if ever. This stockpiling may be done to exclude competing entrants from using spectrum or simply to horde spectrum. This has been a major criticism of government use relating to national security matters.(3) While the allocation table reserves spectrum for a particular use, stockpiling reserves spectrum for a particular user. There are not numerous examples of stockpiling.

In contrast to stockpiling, some portions of the spectrum are allocated to a particular use, and anyone interested in that use, who has the necessary equipment, can obtain a permit. The resulting congestion and interference in these portions of the spectrum are notorious; a prime example is citizens band (CB) radio. Users of this service essentially have a "party line" and anyone with the equipment and the permit can use the frequency whenever he or she wishes and whenever the interference level is low enough for his or her purpose.

The allocation of radio spectrum to users depends on a variety of factors which relate to economics and politics as well as to the technology involved in various uses. Broadcasting use of the spectrum has built-in incentives to protect the status quo once arrived at. That a new entrant or a new user of frequency can easily dislodge an established user is unlikely. Thus, by means of allocation tables, which segregate large portions of the spectrum for users and future users, and the ad hoc, squatter's rights principle which relates to other portions of spectrum usage, there is no easy way that a new technology or technological innovation can be rapidly assimilated into the broadcasting system.

Table 4-1 Example of FCC table of frequency allocations
Source: 47 C.F.R. § 2.106 (1976).

§ 2.106 Table of Frequency Allocations—Continued

Worldwide		Region 2		United States		Federal Communications Commission				
Band (MHz)	Service	Band (MHz)	Service	Band (MHz)	Allocation	Band (MHz)	Service	Class of station	Frequency (MHz)	Nature OF SERVICES of stations
1	2	3	4	5	6	7	8	9	10	11
				37–38	NO.	37–37.01	LAND MOBILE.	Base. Land mobile.		INDUSTRIAL.
						37.01–37.43	LAND MOBILE.	Base. Land mobile.		PUBLIC SAFETY.
						37.43–37.89	LAND MOBILE. (NG59)	Base. Land mobile.		INDUSTRIAL.
37.75–38.25	FIXED. (228) (230) (231) MOBILE. Radio astronomy. (233B)					37.89–38	LAND MOBILE.	Base. Land mobile.		PUBLIC SAFETY.
				38–39	G. (US41)					
38.25–41 (235) (236) (236A)	FIXED. (228) (230) (231) MOBILE.			39–40	NG. (US94)	39–40	LAND MOBILE.	Base. Land mobile.		PUBLIC SAFETY.
				40–42 (US220) (236)	G. (US94) (US210) (US220)				40.66	Industrial, scientific and medical equipment.
41–50		41–60	FIXED. (228) (231) (237) MOBILE. (233A) (236A)	42–46.6	NG.	42–42.93	LAND MOBILE.	Base. Land mobile.		PUBLIC SAFETY.
						42.93–43.19	LAND MOBILE.	Base. Land mobile.		INDUSTRIAL.
						43.19–43.69	LAND MOBILE.	Base. Land mobile.		DOMESTIC PUBLIC. INDUSTRIAL. PUBLIC SAFETY.
						43.69–44.61	LAND MOBILE.	Base. Land mobile.		LAND TRANSPORTATION.
						44.61–46.6	LAND MOBILE.	Base. Land mobile.		PUBLIC SAFETY.
				46.6–47	G.					
				47–49.6	NG.	47–47.43	LAND MOBILE.	Base. Land mobile.		PUBLIC SAFETY.
						47.43–47.93	LAND MOBILE.	Base. Land mobile.		PUBLIC SAFETY. INDUSTRIAL.
						47.93–49.6	LAND MOBILE.	Base. Land mobile.		INDUSTRIAL.
				49.6–50	G.					
50–54		50–54	AMATEUR.	50–54	AMATEUR. (US1)	50–51	AMATEUR.	Amateur.		AMATEUR.

54-68		54-68	FIXED. (256) (257) MOBILE. BROADCASTING.	54-72	NG.	54-72	BROADCASTING.	Television broadcasting.	55.25	Video } Channel 2.
									59.75	Sound } Channel 2.
									61.25	Video } Channel 3.
									65.75	Sound } Channel 3.
									67.25	Video } Channel 4.
									71.75	Sound } Channel 4.
68-73.0		68-73.0	FIXED. MOBILE. BROADCASTING.	72-73 (US20)	NG.	72-73 (NG66)	FIXED. (NG1) (NG3) (NG49)	Operational fixed.	72.02-72.98 (NG33)	Operational fixed.
73-74.6		73-74.6	RADIO ASTRONOMY. (253A) (253B)	73-74.6	G, NG. (US31) (US100)	73-74.6	RADIO ASTRONOMY. (US74)	Radio astronomy.		RADIO ASTRONOMY.
74.6-75.4		74.6-75.4 (250)	AERONAUTICAL RADIONAVIGATION.	74.6-75.4	G, NG.	74.6-75.4	AERONAUTICAL RADIONAVIGATION.	Aeronautical radionavigation.	75	Marker beacon.
75.4-88		75.4-88	FIXED. MOBILE. BROADCASTING.	75.4-76 (US20)	NG.	75.4-76 (NG66)	FIXED. (NG1) (NG3) (NG49)	Operational fixed.	75.42-75.98 (NG33)	Operational fixed.
				76-88 (US23)	NG.	76-88 (NG21)	BROADCASTING.	Television broadcasting.	77.25	Video } Channel 5.
									81.75	Sound } Channel 5.
									83.25	Video } Channel 6.
									87.75	Sound } Channel 6.
88-100		88-100	BROADCASTING.	88-108 (US23) (US93)	NG.	88-108 (NG21)	BROADCASTING.	FM broadcasting. (NG2).	88.1-107.9 (NG26)	FM Channel 201-FM Channel 300.
100-108		100-108	BROADCASTING.							
108-117.975	AERONAUTICAL RADIONAVIGATION.			108-117.975 (US93)	G, NG.	108-117.975	AERONAUTICAL RADIONAVIGATION.	Radionavigation land.	108.05	Omnidirectional range (VOR).
									108.10	Localizer.
									108.15	Do.
									108.20	Omnidirectional range (VOR).
									108.25	Do.
									108.30	Localizer.
									108.35	Do.
									108.40	Omnidirectional range (VOR).
									108.45	Do.
									108.50	Localizer.
									108.55	Do.
									108.60	Omnidirectional range (VOR).
									108.65	Do.
									108.70	Localizer.
									108.75	Do.
									108.80	Omnidirectional range (VOR).
									108.85	Do.
									108.90	Localizer.
									108.95	Do.
									109.00	Omnidirectional range (VOR).
									109.05	Do.
									109.10	Localizer.
									109.15	Do.
									109.20	Omnidirectional range (VOR).
									109.25	Do.
									109.30	Localizer.
									109.35	Do.
									109.40	Omnidirectional range (VOR).
									109.45	Do.
									109.50	Localizer.
									109.55	Do.
									109.60	Omnidirectional range (VOR).
									109.65	Do.

See footnotes at end of table.

Constraints on Broadcast Program Content

The content of broadcasters' programs is an important aspect of communication. In theory, the free speech and free press provisions of the First Amendment of the U.S. Constitution protect broadcasters as well as the more traditional forms of expression. Interestingly, there are several means by which the regulatory powers of the FCC have been used to inject certain, minimum standards which broadcasters must meet in order to satisfy the statutory requirements of licensing. These requirements are based on the maxim that a license holder must perform to meet the public interest. The judge of whether the broadcaster has met the public interest is the FCC and this is done when a license is renewed every three years. In this way the FCC has gradually established a set of criteria for judging whether the public interest has been served by the kind of programming which the broadcaster has presented or proposes to present under the license. Few denials of licenses or renewals have been based on the kinds of programming offered, but that may be because most broadcasters have met the minimal FCC requirements.(7)

Even in the absence of formal program controls, certain economic considerations structure the content of programs that mass communication broadcasters present.(1) The need to attract the largest audience possible requires that the programming attract the viewer or listener. That means that the programming must be either unique, if the advertiser is seeking to reach a particular and specialized audience, or, more likely, that it be attractive to the largest possible set of buyers. The attraction of the largest audience possible tends to prevent use of the mass media for particularized or unique audiences, and it dictates

that the programs presented be widely acceptable in content and tone.

The fear of audience "fractionation" which would splinter audiences into particular groups has long been an argument by some against certain kinds of technology, such as cable TV, which would facilitate particularization of audiences. Audience fractionation has become a common phenomenon for AM radio which now presents rather narrow and specialized programming. Mass audience, TV network programming, based on the delivery of large audiences to sponsors, could not function profitably as it does now with specialized programming or fractionated audiences. While one might argue that specialized programming would improve the "quality" of the programs offered, quality is a subjective evaluation. Many observers argue that the market determines the program content currently, and nothing should be allowed to change that--whether it be programming requirements or technological innovations which make fractionation possible and profitable.

Examples of Broadcast Technology Development

Discussions to follow illustrate some ways in which technological development and usage in the broadcasting industry have been encouraged or hindered by policies. In particular, the FCC has sought to achieve a variety of explicit and implicit policy objectives with regard to technology by pursuing various policies over particular spectrum allocation questions. The kinds of issues they sought to address, the means they chose to achieve their particular ends, and the outcomes of these efforts will be outlined.

UHF Television

In 1962 Congress enacted the All-Channel Receiver law which gave the FCC statutory authority to re-

quire that all television sets sold in interstate commerce be capable of receiving all television channels. (See Appendix).(6,8) This was not an isolated piece of legislation but rather an overt attempt by the FCC to foster the use of UHF television channels which it had made available as part of the original allocation table for television in 1952. In the 1952 allocation, the FCC announced that it sought to encourage the development of diversity of programming for TV by increasing the number of stations on the air and to provide the maximum number of local television stations.(9) To do that, the VHF spectrum was inadequate, so a substantial portion of the UHF frequency was allocated for some 70 television channels. In doing this, the FCC increased the number of channels from 12 VHF to a total of 82.

These developments to encourage diversity and the proliferation of stations and programming by increasing the channels available may not be sufficient to produce the results the FCC sought. As the data presented in Figure 4-1 indicate, the number of UHF stations on the air, compared with VHF stations, shows that the growth of UHF stations has been slow, despite the fact that the number of potential UHF assignments is much higher than VHF.

A variety of economic and technological factors accounts for this failure of UHF television to develop.

First, technologically, the UHF portion of the spectrum is not as good a media as the VHF spectrum for broadcasting television. The UHF broadcast of television is subject to a number of local interference problems, such as tall buildings and other structures. Furthermore, energy radiated at UHF wavelengths attenuates much more rapidly than does energy at VHF wavelengths, so UHF signals do not carry as far as VHF signals. Thus, the UHF spectrum is not as attractive as is VHF spectrum for the TV broadcaster. Audience size is generally

smaller for UHF because of smaller viewing area and a frequently poorer picture quality. The smaller audience sizes mean that the advertising income for a UHF station will be less than for a comparable VHF station with identical programming.

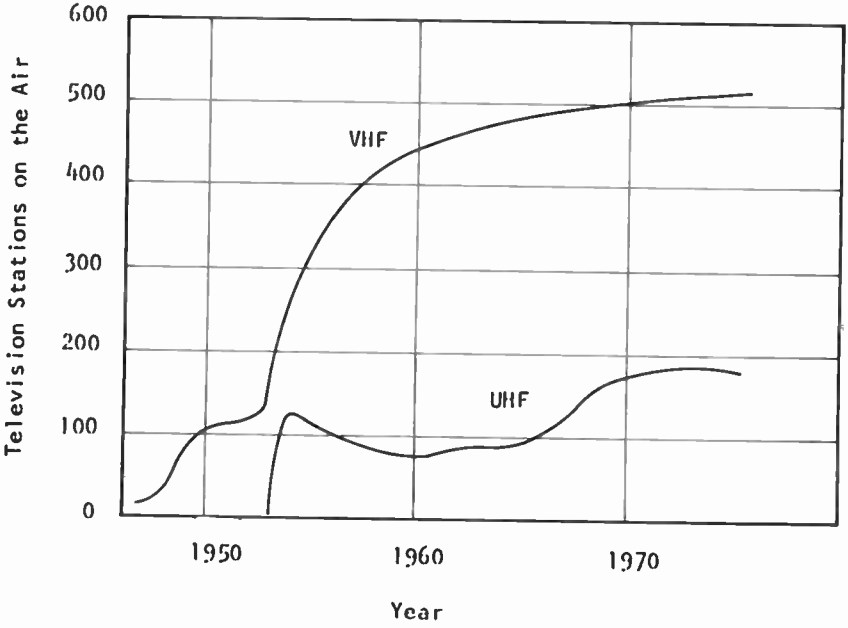

Figure 4-1 Television stations on the air in the United States, by year. Source: *Television Factbook,* Volume 46, 1977 edition.

A second important constraint on the development of UHF audiences in the 1950's was the simple fact that the standard television receiver could not receive UHF signals. In the 1950's as television was developing, manufacturers produced sets which would only receive signals then on the air, and there were VHF only. To receive UHF signals in the 1950's, a viewer not only had to opt for a poorer quality of picture, but also had to purchase a

separate converter or a special television set. Given the fact that most broadcasts in this period were VHF, it was difficult to find much enthusiasm for UHF TV. The All-Channel Act of 1962 was an obvious effort to increase the availability of UHF receivers. Figure 4-2 indicates that, when the UHF regulation became effective in 1964, the number of sets built increased, and these included the UHF tuner. Whether this reflects a higher demand for such sets because they contained the UHF tuner or just the efforts of manufacturers to increase sales is unclear. However, if the increased production represents the demand for UHF sets, then the number of UHF viewers was not very great in comparison with VHF viewers. It is not clear that the All-Channel Act satisfied an existing demand for UHF receivers, but it did increase the number of potential viewers who could watch UHF stations.

The effect of the All-Channel Act on the development of UHF, or, more generally, the development of UHF as the source of program diversity and local programming, has been unclear.(9) The UHF television industry does not seem to be economically profitable for most of its members.(2) This problem exists today, well after the majority of television sets are capable of receiving UHF signals along with VHF and well after many FCC efforts to encourage development of UHF. In fact, many UHF stations are not profitable, and, even among those which are profitable, the amount of profit is much lower than comparable VHF stations. (2) Many reasons for this lack of UHF success and the under utilization of the spectrum allocated for this use have been suggested.

Technical problems still exist and over-the-air UHF broadcasts frequently are not of the same quality as VHF broadcasts. Possibly, if sufficient economic or other incentives were presented, new technologies could produce a better UHF signal, but such a development appears unlikely. Recently, the

FCC has required that a detent or "click" tuner be incorporated into all UHF receivers.(10) This requirement will make selection of UHF channels easier, but the impact of this requirement cannot be predicted.

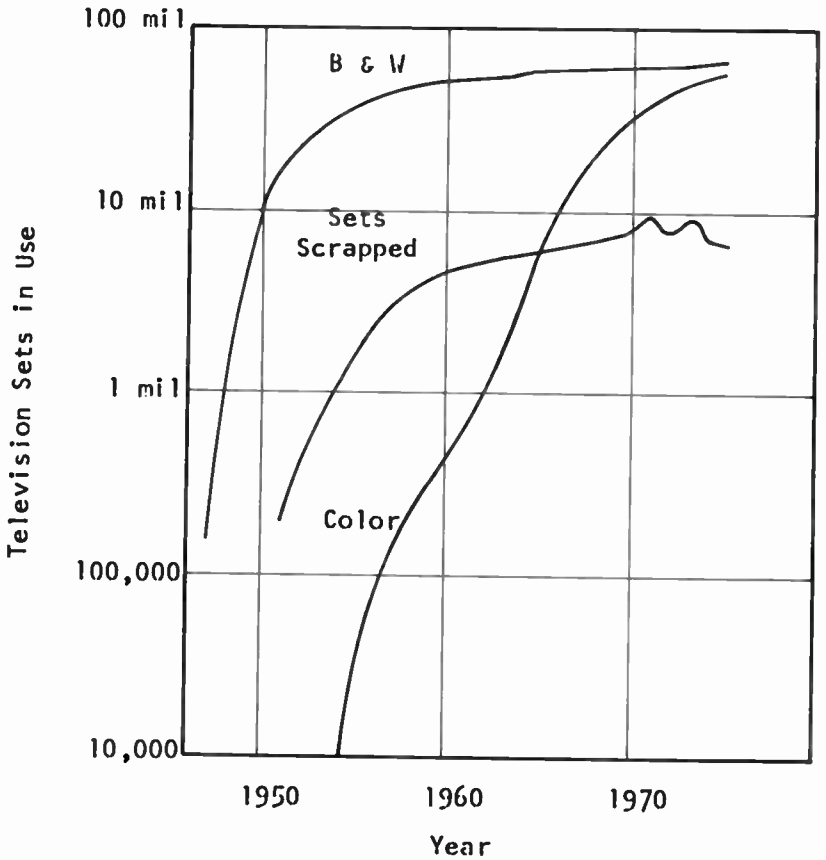

Figure 4-2 Television sets in use in the U.S., by year. Source: *Television Factbook*, 1974-75 edition.

Another possible reason for the UHF problem is program content. Many UHF stations are not network affiliates and rely on local programming. This

means that the programs available are movies, syndicated programs, rerun serials, and sports events. This type of program is unlikely to attract a sufficient audience to make the operation profitable. (1) One exception to the lack of profitability of local programming has been the televising of major sporting events. However, this is limited to large metropolitan viewing markets. Some UHF stations have been able to operate profitably by appealing to a specialized or particularized audience, such as foreign language stations in Los Angeles and New York. Such audience fractionation into localized groups may be exactly what the FCC policy is designed to do. However, the economics of television programming suggest that fractionated audiences do not provide a viable economic basis for the successful operation of a television station. The programming problem is circular since without profitable operation attractive programs cannot be obtained, and the UHF broadcaster cannot become profitable unless it has more attractive programming.

Deintermixture. The FCC has tried other policies to stimulate UHF broadcasting besides the All-Channel Receiver Law. In the 1950's and early 1960's the commission sought to deintermix viewing areas. That is, all the broadcasters in one viewing area would be assigned UHF channels and in another, VHF. The result would be that all the local broadcasters would have equal technical factors to deal with, and UHF would not have to compete with the higher quality VHF broadcasters. In addition, the viewers in an area could supposedly purchase either a UHF for a VHF television set and be able to receive all the broadcasts in the area. There was a good deal of political opposition to the deintermixture proposals, even though the FCC did institute the policy on a trial basis in several areas.(6) The VHF broadcasters opposed having to give up their valuable and

qualitatively better channel assignments where they faced a UHF assignment. The viewers in VHF areas which were slated to become UHF areas seemed to be opposed if for no other reason than that they would have to purchase a UHF receiver. When the FCC proposed the legislative action in 1962, it combined certain deintermixture proposals with the all-channel proposal. Then, to gain support for the All-Channel Act among various groups, the commission agreed to drop the deintermixture proposal in return for support for the All-Channel Act from broadcasters and viewers.

Politics of the All-Channel Act. In order to understand the politics of the All-Channel Act, it is useful to reexamine the events leading up to it. The FCC had early made a major decision to foster diversity in TV programming through licensing new broadcast stations in the UHF band. Unfortunately, UHF reception is frequently of much poorer quality and requires a different tuner than VHF. Thus, few viewers were attracted in areas where VHF channels were available, and few television sets were manufactured with capability of receiving UHF channels. A UHF license, in many areas of the country, was useless, even if the UHF broadcaster was a network affiliate.

The FCC considered various policies designed to increase the attractiveness of UHF channels to broadcasters besides deintermixture. Along with its effort at deintermixture, the FCC began to lobby in Congress for the authority to require that television sets be capable of receiving UHF. The commission's proposal on deintermixture was opposed by the broadcasters and the networks which stood to lose VHF channels and the congressmen who represented the viewing areas that were designated for deintermixture to all UHF. As a result the FCC dropped its deintermixture efforts in return for support from the broadcasters and networks for the All-Channel Act. The equipment manufacturers gen-

erally supported the act even though it would increase the cost of their sets. The UHF broadcasters supported the act because they stood to gain some viewers simply because the viewer could now receive the UHF broadcasts. Some viewers apparently also supported the legislation because they valued increased diversity. These people all stood to gain something from the UHF requirement. The people who would pay the costs of the act were the new purchasers of television sets, but at that time consumer interests were barely organized and although several Congressmen mentioned the increased cost to the buyer (estimated at from $20 to $45 per set), no significant opposition came from the purchasers of television sets.

The technopolitical model for UHF TV is shown in Figure 4-3. The final outcome was the All-Channel Act which was ultimately supported by the established industry (networks and VHF TV broadcasters) and consumer groups (viewers against deintermixture) as an acceptable compromise. New entrants (UHF TV broadcasters) also supported the policy. The result of the decision was generation of a substantial market for UHF tuners and an increase in potential UHF viewers.

CATV Systems

At about the time that the FCC was initiating its UHF policy to achieve localism and program diversity among television broadcasters, cable television (CATV) had its beginnings. (Initially the acronym CATV stood for community antenna system, but is now universally understood to stand for cable television.) CATV systems developed in rural and mountainous areas where over-the-air reception of television signals was difficult or impossible. They operated with a high antenna, placed on a mountain top, which permitted clear reception of distant television signals. The received signals were then amplified and distributed by a cable to

the homes of subscribers either a short distance or many miles from the antenna. VHF reception, as well as UHF reception, is hindered by distance and other obstructions. Thus, various local entrepreneurs in these communities began to build cable distribution systems to improve the television reception in the area.

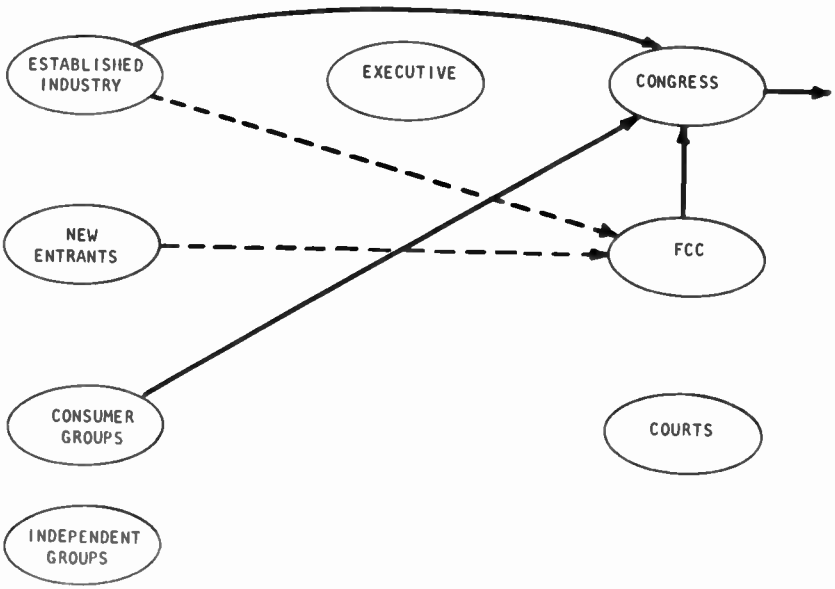

Figure 4-3 UHF TV All-Channel Act Model

Established industries included the UHF equipment manufacturers, the UHF broadcasters and VHF broadcasters. The equipment manufacturers sought increased markets for UHF sets. UHF broadcasters stood to gain some viewers, and VHF broadcasters could defuse the deintermixture issue by supporting the bill.

New entrants included potential UHF broadcasters who would enter the market if there were more potential viewers.

Consumer groups supported the increased diversity in programming.

The Federal Communications Commission also lobbied strongly for the enactment, to support its policy of localism in broadcasting.

One of the attractive features of CATV is that it can receive distant signals by placing a pick-up antenna near the TV station, relaying the signal back to a central location, and distributing it to the homes of viewers. For a monthly subscription fee, the viewer can not only receive pictures from local broadcasters but also can receive additional, high-quality signals with the programming available from large, distant viewing areas. In effect, this increases the viewing audience of the distant signals. However, these signals were imported and distributed by CATV systems without the payment of any fees to the program copyright holders or the television broadcasters. The CATV system paid nothing for the programs which it distributed to its subscribers. The fee it received was only for providing the distribution service to viewers.

In the 25 years or so since cable television began developing, it has become the major source of a potential electronic revolution in the home. It has developed, technologically, to a point where it can provide a vast array of services to the home ranging far beyond the original function of distributing television broadcasts. Cable can carry more "channels" than can be broadcast over-the-air in any one location; some observers say 30, 40 or even 80 cable channels. No TV reception area has more than 12 to 15 operating stations.(2) Cable can also provide a two-way capability so that subscribers can respond to messages it carries. A cable system does not use radiated signals in the electromagnetic spectrum. While it may obtain a portion of its programs from over-the-air transmissions, the cable system, itself, does not broadcast. Rather, it distributes all the signals through a coaxial cable. The cable system conserves spectrum in that it does not utilize radiated signals in its distribution process. While the distant signals do use portions of the spectrum, no additional spectrum is required for their distribution over the cable system.

The technical possibilities for CATV have led some observers to call cable "the television of abundance."(11) This technology presents the possibility of providing program diversity using many distant signals to yield a variety of programs and providing special purpose channels which, unlike UHF, do not occupy any portion of the spectrum. CATV systems in local areas are affecting the FCC objective of developing UHF TV for local stations and program diversity. As a source of program diversity, cable does not suffer from the reduced quality of pictures, which is a major problem with UHF broadcasts. A CATV system can present a large number of signals, all of high quality and with considerable diversity. The distribution of UHF signals over the cable can increase the potential viewing audience for UHF.

The regulation of CATV has been done almost entirely by local governments. Through franchising a CATV system, the local government gave one cable company a monopoly in the viewing area, obtained a franchise fee (usually a fixed percentage of the subscription charge), and provided the local citizens with the opportunity to see programs not available over the air. However, in the late 1950's, the established broadcasters began to agitate for more extensive and protective government regulation of CATV. Initially, the FCC declined to regulate cable as a common carrier since the CATV systems did not have the usual characteristics of common carriers.(12) Then, under continued broadcaster pressure, the commission sought statutory authority from Congress to regulate cable. In the early 1960's Congress failed to enact such legislation, and the FCC faced the need to regulate cable without specific authority. Coming in the back door, the FCC in 1962 began to regulate cable systems which used microwave carriers to obtain their signals.(13) The commission restricted the kinds of television signals which the microwave

carriers could supply and thus the kinds of signals which CATV systems could obtain. In this fashion, the FCC specified carriage and nonduplication requirements which limited CATV offerings. These requirements were extended to all microwave-served cables in 1965.(14) However, CATV systems which did not use microwave as a source of distant signals were unaffected by these FCC regulations.

During the 1960's the CATV systems expanded greatly both in terms of the communities served and in terms of the number of subscribers using cable. Figure 4-4 illustrates the growth of CATV systems and the increase of subscribers to those systems. The data indicate that the major growth in the number of subscribers began in the mid 1960's. Also, the number of subscribers per operating system began to increase markedly in the same period. The saturation rate or number of CATV subscribers as a percentage of TV homes is 15 percent, although in some markets, the ones in which CATV has been operating for some time and where CATV provides an attractive viewing alternative, the penetration (homes served as percentage of homes passed by cable) can range from 60 to 80 percent (the national average is 55 percent). The growth of CATV in the 1960's was not due directly to the FCC regulations. In fact, the development was more likely due to the affluence of the population in the 1960's and the drastic increase in color television programming. The growth in subscribers per CATV system indicates that the penetration rate began increasing sharply in the mid 1960's.

In 1966, the FCC issued a Second Report and Order which exerted FCC jurisdiction over all CATV systems and required that in order to import distant signals into the top 100 viewing markets, the cable company had to have express commission approval.(15) The commission's concern with this set of regulations was the fractionation of viewing audiences in large-city UHF markets. The FCC saw

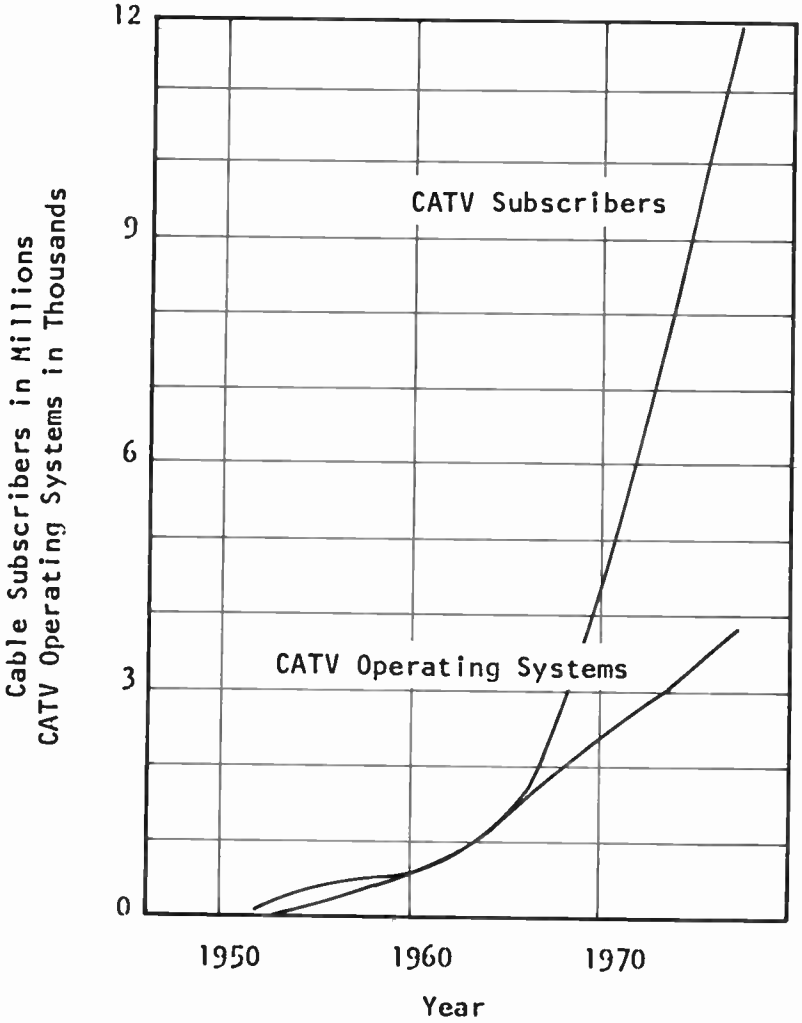

Figure 4-4 CATV systems in operation and CATV subscribers by year. Source: *Television Factbook,* Volume 46, 1977 edition.

cable as an important part of small community viewing, but the protection of its large-city UHF broadcasting efforts was uppermost in the commission's mind, even though the UHF plan was origi-

nally designed to provide small communities with a local broadcaster. The U.S. Supreme Court upheld the commission's exertion of jurisdiction over all cable systems in 1968 but limited that jurisdiction to that which was reasonably "ancillary" to the effective performance of the commission's direct statutory authority to regulate over-the-air broadcasting. (See Appendix).(16)

This court interpretation is important because it provides the commission with authority to deal with cable only in relation to over-the-air broadcasting not as a separate and independent communications industry. Cable regulations must be tied to established broadcasting matters. In 1968 the commission issued an interim set of rules to govern cable during the period in which the FCC studied the cable issue comprehensively. These temporary rules maintained the restrictions on importation of distant signals in the top 100 markets. The rules required the cable company to offer some program origination of its own, apparently trying to extend FCC control over cable by making cable into "broadcasters" in the usual sense. The origination requirements were dropped by the commission in November 1974.(17)

The commission issued its first major set of cable regulations in 1972, after an extended period of study.(18) These regulations will structure the development of CATV during the 1970's, and they have already had a significant impact on the cable industry.(19,20) These regulations reflect a partial compromise between the established broadcast interests and the cable companies. The major gain for cable was limited entry into the top 100 markets, although there are complicated restrictions relating to signal importation and nonduplication of local signals. When the regulations were issued, the signal importation restrictions would allow all of the top 100 markets to obtain at least one distant, independent signal over the cable and at most

three independents.(21) The effect of this was to protect local network affiliates and to allow distant competition for local independents. The number of distant signals imported decreases as the market position of the viewing area decreases. Thus, localities that are smaller markets can import fewer signals.

As one of the major requirements of the 1972 regulations, the FCC stated that it was time for cable to start providing some of the vast technological potential which many observers had discussed for sometime. To facilitate this, the FCC requirements provided that all new (post-1972) and all established cable systems (by March 31, 1977) must have the capacity for 20 channels of offerings.(22) This compliance deadline has been extended until June 21, 1986.(23) In addition, the system must be capable of providing rudimentary two-way communication, so that the viewer can provide a yes-no or on-off response to a transmitted request from the head-end.(24) The regulations require that the cable system provide one public access channel each for such things as education, local government, and a public forum.(25) However, these access channel requirements were reduced to one channel until demand for more is evident.(26) These are to be provided free for the first five years of operation. Table 4-2 indicates the recent development of channel capacity and two-way capability in CATV systems. The growth can only be shown for the years since the 1972 regulations. However, the data indicate that an increasing proportion of systems have the required capabilities. The extent to which these capabilities are being used is unknown, but the number of two-way operating systems is quite small, and these are being tried on an experimental basis.

CATV and Copyright. A major problem which was not settled by the 1972 regulations was in the copyright dispute between cable companies and the

holders of program copyright privileges. Most of the CATV industry were willing to pay some copyright fee for the use of programs. However, the dispute was over how much the payment should be and the means of making the payment. The Congress repeatedly considered proposals to require such copyright payments, because the Supreme Court twice held that CATV systems do not "perform" a program under the then existing copyright law and therefore are not liable for copyright fees under the 1909 statute.(28,29)

Table 4-2 Channel capacity of CATV systems

Capacity \ Year	Number of CATV Systems						
	1969	1970	1971	1972	1973	1974	1976
Not available	140	164	118	65	46	31	11
5 or less	572	520	421	387	336	267	189
6-12	1559	1720	1882	2026	2181	2320	2647
Over 12	29	86	157	361	-	-	-
13-20					262	293	424
Over 20					207	297	444
Total	2300	2490	2578	2839	3032	3190	3715

Source: *Television Factbook*, Vols. 39-46 (1969-77).

In October of 1976, Congress adopted a major revision of the Copyright Law.(30) It becomes effective on January 1, 1978, and one of its major provisions is the inclusion "secondary transmission" by CATV systems under its provisions.(31) Such cable systems must deposit royalty payments and file accounts with the Register of Copyrights for distribution to the copyright holders. The act also creates a Copyright Royalty Tribunal, empowered to determine the royalty rates for CATV owners, among other things.(32) What effect these regulations will have on the development and oper-

ation of CATV systems cannot be predicted at this time. It is safe to say, however, that the copyright expenses which some cable operators will now incur, will undoubtedly increase the costs of operation and make entry into the cable business less attractive.

CATV Technopolitical Model. With the technology of CATV, the opportunities for development are present. The restrictive features of the situation depend on what is economically attractive under current regulations. While economics can be viewed as the primary controlling variable, the economic market place is narrowly confined by government regulation and political pressure from various interests. Thus, the primary factor is more likely to be the openness with which the regulator permits entry and utilization of the new technologies.

Regulatory commissions have frequently been charged with protection of the industry which is supposedly regulated. Protection can come in the form of excluding new, competitive entrants, or in the form of rate protection from lower, competitive suppliers of the service. As such a regulator, the FCC has been caught between the legislative direction to regulate in the "public convenience, interest, and necessity," and the demands from established, politically-strong broadcast interests which seek protection from various competitive threats. The policy results of the FCC have often been either in favor of the status quo--the established industry--or to permit only slight and limited entry of new services or technologies. The effect of such parameters on the development of technology and its utilization would seem clear. Generally, the new technology will not be permitted to compete with or replace the existing technology which has the advantage of being in-place and operating. Thus, while cable technology provides a pandora's box of technical possibilities,

the realization of any of these will depend on political decisions by Congress and the regulatory agencies, as well as the general political climate, the Executive Branch, and the courts. The current cable regulations are a prime example of limited competitive entry for the new technology in the face of the established interest's pressure for protection.

The major participants in the CATV area are the established, over-the-air broadcasters, the networks, the program producers, the CATV operators, and various equipment manufacturers (both for cable technology and broadcasting). The results of the political interplay of these forces vary, but it appears that the established interests have not been losers in terms of policy. The 1972 cable regulations open the top 100 markets to CATV systems, but the restrictions on signal importation and other programming limits indicate that the over-the-air broadcasters in these markets are still in a secure position. The cable interests accepted the 1972 regulations as part of a compromise arrangement negotiated by the Office of Telecommunications Policy in the White House. Most CATV operators saw getting a foot in the door of the top viewing markets as a gain. However, as it has turned out, the door was barely opened, and current capital markets make it unlikely that many CATV systems will venture great amounts of investment in these markets at this time.

The system model for the CATV allocation process is shown in Figure 4-5. The ultimate policy represents a prevailing of the views of the established industry (TV broadcasters), an independent group (Sloan Commission), and the Executive Branch. The new entrants (CATV companies) strongly opposed the limitations on imported signals and the anti-siphoning rules which adversely affected their marketability. The net technological result was a requirement to update existing systems to a

specified level but to provide little incentive for further development.

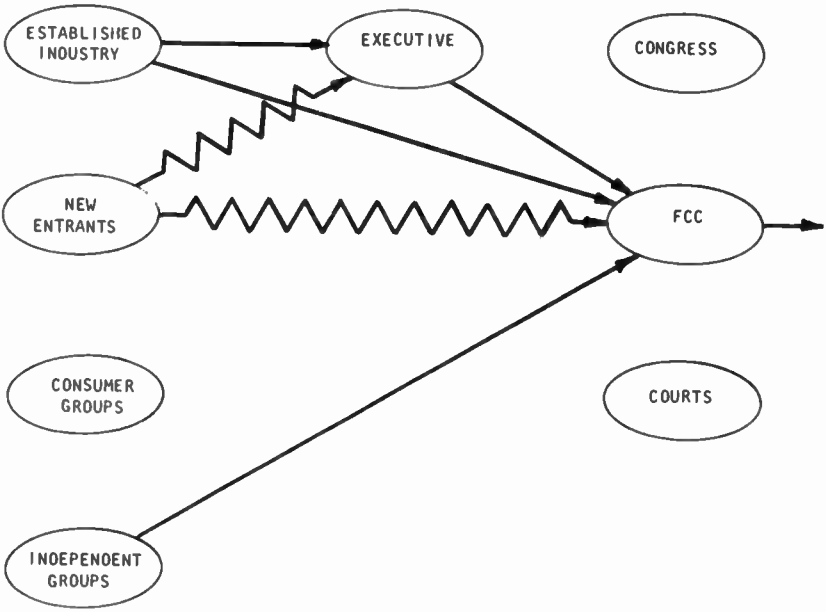

Figure 4-5 CATV allocation model

Established industries include operating, over-the-air broadcasters who sought to impose severe limitations on CATV operation in the top viewing markets through FCC regulations and White House pressure.

New entrants were the CATV systems, seeking to receive some economic and technical opportunities in the large viewing markets by means of favorable FCC rules.

Independent groups included the Sloan Commission and the Ford Foundation which provided studies of the capabilities of cable television systems and advocated a policy middle ground.

Pay Television

There are alternatives which CATV systems can pursue to obtain various kinds of income from viewers

other than providing distant, over-the-air signals. One of the more promising seems to be some form of pay-TV. Pay-TV is based on the principle that the viewer pays for what is watched, either on a per program or on a monthly fee basis. There are various procedures for payment of the fee, and there are various technical means of insuring that only those who have paid, receive the signal. Normally the signal (which need not be carried over a cable and can be broadcast over the air) is scrambled so that a regular television receiver cannot present the video portion of the signal, unless a converter has been placed in the viewer's home and has been activated by a card or a switch at the CATV office. The programs watched can be logged at the office of the cable company, and the viewer billed regularly, or the viewer can pay for the card before he uses it, and thus he purchases a "key" which will permit him to view a selected set of offerings.(33)

The pay-TV concept has certain attractions since it does permit the viewer to register his preferences for programming directly by choosing to "buy" or not to "buy" individual programs.(1) Thus, in theory, programs which are not profitable can be determined by the market immediately rather than after viewer ratings have been registered, and advertising has sold or not sold particular products to consumers. The individual program can be directly measured in terms of its economic power.

In addition to these aspects of pay-TV, the broadcaster or CATV operator directly receives the income from the programming he provides. That is, the income is not obtained by the commercial advertiser who in turn pays the broadcaster for the continued presentation of the program. The cable operator receives no revenue from the advertiser, so the payment to CATV systems would be direct, rather than indirect through subscriber fees. For cable, the subscriber would still pay for being

wired into the CATV system and would then pay an additional fee for the privilege of viewing the selected programs on the pay-TV channel. A major attraction of pay-TV is that it would permit a cable system to present specialized programs, which only a few viewers would watch and which would be paid for by those who want to watch them. This would have the effect of fractionating the audiences, but the viewer who wanted to see a mass audience program or could not afford to pay for a special program would not have to do that. Thus, some see pay-TV as the means to "improving" the quality of television programming and at the same time permitting direct payment for those program changes.

However, there are strong arguments against any sort of pay-TV system, whether over-the-air or cable. First, only those people who can afford to pay for the service would be able to watch it. While all viewers have to purchase a television receiver, they do not have to purchase the advertised product on commercial broadcasts. Thus a free-rider situation can and has developed in the existing system since many people watch programs but pay little if anything for those programs. It appears that a pay-TV system does screen out particular, low economic strata of the viewing population. Either because they are unable to afford the pay-TV service or because the programming is not attractive to them they are screened out. The experiments done with pay-TV did not attract many viewers from these economic and social strata. The extreme argument here indicates that eventually the only television viewers would be those who could afford it, and a large portion of the viewing audience would be eliminated. Furthermore, the programming available under a pay-TV system, if fully developed, would be much different than the mass audience programs currently offered free to the viewer. Whether this change in program con-

tent is desirable is debatable. Certainly some view the "quality" of current programming as poor, but "quality" depends on the tastes and preferences of the individual and many see current programming as acceptable in quality.

In addition to these economic factors relating to pay-TV, the Federal Communications Commission has strongly regulated the kinds of programs for which a pay scheme can be arranged. "Siphoning" of programs off the air or away from the commercial broadcaster, as it is called, is viewed with great suspicion by broadcasters and by the FCC. This would allow the pay-TV proponent to purchase the "cream" of programming and then charge for it. The commercial broadcaster on the other hand, must not only pay for the same program, without the direct income for pay viewers, but must then set a price to advertisers which is economically attractive before he can air the program. The result of no anti-siphoning regulations would be, so the argument goes, that the only programs the over-the-air broadcaster could afford would be unattractive to most viewers and thus the broadcasters' revenues from commercial advertisers would decline to the point where the broadcaster would be unable to make a profit from his operation.

As a result, the FCC has imposed anti-siphoning regulations which prohibit a large number of programs from being aired through a pay-TV system. The regulations now permit showing only of movies which are less than three years old or over ten years old, and sports events which are not normally aired live or have not been shown live during the past five years by any local broadcaster.(34)

Thus, the only markets available to pay-TV are current or very old movie markets and restricted sports audiences. This may be an adequate market for pay-TV to begin airing a channel of this sort.

However, the FCC has permitted over-the-air pay-TV only on an experimental basis until quite

recently. The experiments indicate that the marketability of over-the-air pay-TV is primarily to specialized audiences. Currently, some cable companies are providing pay-TV services either on a regular basis in some selected viewing markets or as a closed circuit pay-TV system for hotels. These appear to be the primary points of entry for pay-TV currently, and these are very limited efforts at this time, although the Cox Cable Company has 25,000 pay-TV customers in three systems and Teleprompter has 32,000 in four systems.

Whether pay-TV develops will depend on several factors, including the FCC siphoning regulations. The economics of acquiring programs for pay-TV audiences will have much to do with its success or failure. The kinds of programs which cable operators can provide for pay-TV viewers will depend on how many people are interested and how much money they are willing to pay for the added attraction of specialized programs, compared with mass audience, commercial programming.

Radio Broadcasting

The radio broadcasting industry is the oldest user of the electromagnetic spectrum to reach mass audiences in the United States. The technology was originally developed in the years before and during World War I, and the first extensive commercial use occurred in the 1920's. The original technology involved amplitude modulation (AM), and only later, in the 1930's, was frequency modulation (FM) developed to provide a higher quality signal than AM. The AM system of broadcasting is the most heavily used in this country, in part, because it was developed earlier, in part because it does not use as much spectrum, and in part because its lower transmission frequency provides much greater geographical coverage. A frequency allocation for AM broadcasting involves 10 KHz of bandwidth while a single FM broadcast frequency requires 200 KHz of

bandwidth. Thus, approximately 20 AM radio broadcasters can be accommodated in the bandwidth required for one FM broadcaster. In addition to the historical and technological reasons for the heavier use of AM broadcasting, the FCC's regulatory response to these two kinds of broadcast techniques has been different in the early years of each one's development.

Figure 4-6 provides estimates, by year, of the number of AM and FM broadcast stations on the air.

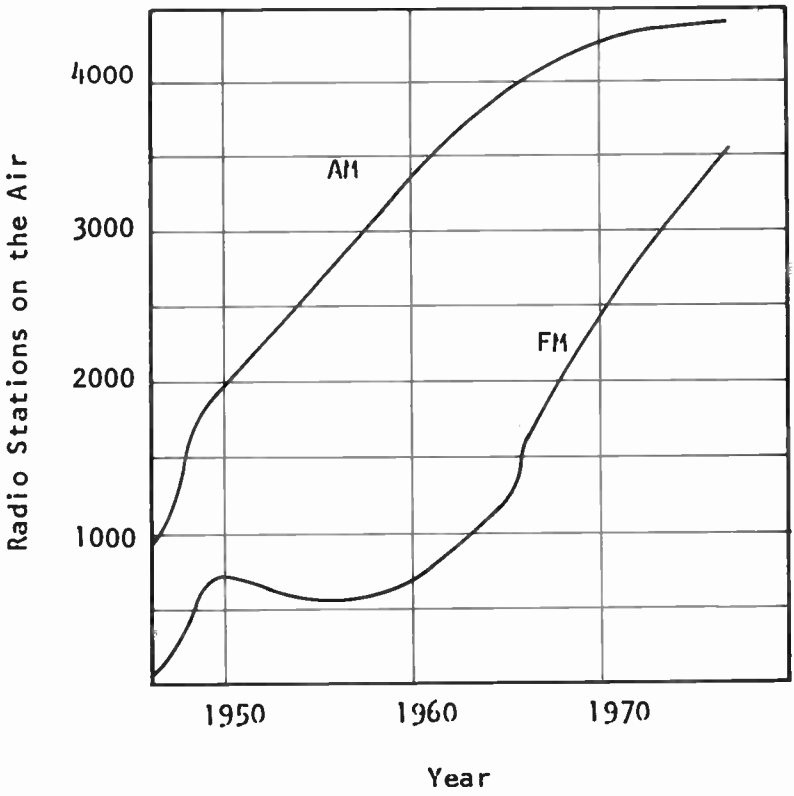

Figure 4-6 Radio stations on the air in U.S., by year. Source: *Television Factbook*, Volume 46, 1977 edition.

These data show several things. First, even though data for the first 20 years of AM broadcasting are not presented, it is clear that the number of AM stations has grown primarily in the period from 1946 (913) to 1974 (4407). Thus, the intensive development of the AM spectrum has occurred largely in the past 30 years and is probably due largely to the technological developments of this period. Such devices as directional antennas and limited FCC license allocations (limited to specific times of day or power) have permitted a tightly packed allocation for AM.(2)

A second general conclusion regarding these data is that the development of FM, occurring wholly since World War II, has been much more gradual than that of AM until recently. One of the major events was a reassignment in 1945 of FM to a higher portion of the spectrum. This came in connection with the initial allocation of VHF television channels and the reassignment resulted from the desire of VHF television broadcasters to have the initial assignments which had been made to FM on an experimental basis in the early 1940's.(6) One result of this reassignment was that the original FM receivers and transmission equipment were made ineffective. The FM broadcast industry had to begin afresh, with new transmitters and new receivers after the reassignment. In addition, the cost of manufacturing FM equipment has been relatively high until quite recently. While an AM receiver costs varying amounts from less than $20 upward, the cost of FM receiving equipment has been much higher. Only within the past five years or so has the cost been reduced to the point that people could buy such equipment easily and at a reasonable price. The technology has only recently reduced the cost of such equipment to within the reach of most radio users.

Figure 4-7 shows the estimated number of radio receivers in use from 1950 to 1974. The growth

rate of radios in use has been much greater than the growth rate of population in the United States.

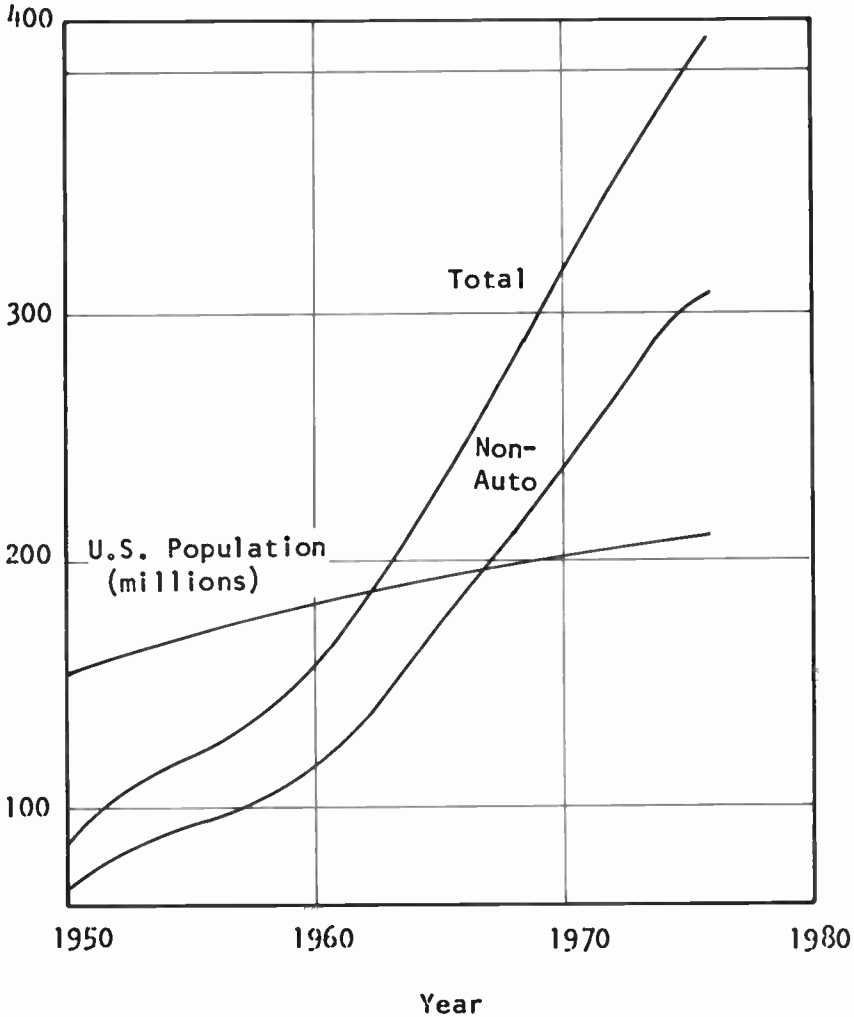

Figure 4-7 Estimated radio sets in use in U.S., by year. Source: *Television Factbook*, Volume 46, 1977 edition.

In fact, the number of receivers exceeded the population in 1963; this event occurred at about the time that the transistor became widely used in the construction of inexpensive radio sets. Since that time, the number of sets and the rate of increase has been much greater than the population, probably due to further improvements in the technological capability to build inexpensive receivers. The number of receivers in automobiles has grown at a much slower rate than "other" receivers. This is important to note in light of recent FCC efforts to initiate automobile radio receiver policies. This subject is discussed below.

Most of the growth of FM broadcasting has occurred since the early 1960's.(35) The assignment of construction permits to FM stations has exceeded the number on the air, just as the AM assignments are greater than those on the air. However, the proportion of AM station assignments that are on the air has consistently been much higher than the proportion of FM stations on the air. Table 4-3 shows the percentage of stations on the air of the total licensed. Although FM percentages have been steadily increasing, they have been only rarely above 90 percent while AM has been above 90 percent since 1950. This might suggest something of the financial difficulties FM broadcasters have in getting the needed capital, in comparison with AM broadcasters, to build and begin operation of the station. In addition, it may also suggest the relatively better chance of obtaining FM licenses than AM licenses in most areas.

The pre-engineered allocation table used for assignment of FM broadcast frequencies has not produced the same kind of congestion incentives for technological innovation which AM has seen.(2) Since the bandwidth of FM stations is known, and each FM frequency has been designated and is waiting for a potential broadcaster, a new entrant

knows what frequencies are still available in his broadcast area, when he seeks a license. Thus, the "protected" status of FM frequencies means that there is not likely to be much outside pressure unless there are more applicants seeking licenses in a region than there are allocated stations. So far that has not occurred, even in the largest population centers.

Table 4-3 Percentage of AM and FM licensed broadcast stations on the air, 1946-1974

Year	AM	FM	YEAR	AM	FM
1946	87	16	1960	92	80
47	65	20	61	96	80
48	81	37	62	94	79
49	88	70	63	96	80
1950	91	91	64	94	83
51	93	95	65	97	75
52	95	97	66	98	88
53	94	94	67	98	86
54	93	91	68	98	88
55	96	94	69	99	91
56	96	96	1970	98	92
57	96	94	71	99	90
58	97	91	72	97	91
59	96	83	73	98	90
			74	98	89
			75	98	89
			76	98	90

Source: *Television Factbook*, Vol. 46 (1977).

FM programming has developed in a specialized fashion. Based largely on the high fidelity of FM broadcasting, the programs have frequently been designed to appeal to audiences who are interested in high quality sound reproduction, such as opera or classical music enthusiasts. More contemporary programming has appeared on some FM stations, but some of the highest revenue producing programs, such as those aimed at teenage groups, are often not carried on FM. Even if these were broadcast on FM, the absence of a large supply of FM portable and automobile receivers, would mean that the broadcaster would reach only a small portion of the potential market.

In recent years audiences have become more concerned with the quality of reception. Frequently such individuals have their own custom sound systems as an alternative to listening to FM radio. Stereo and quadraphonic sound systems tend to replace FM broadcasts among many potential FM listeners. The alternatives to FM listening are likely to be more attractive because they permit listeners to select exactly the kind of music or other entertainment they desire. At the same time AM radio provides an acceptable level of quality for a large segment of the listening audience.

The Federal Communications Commission has pursued a variety of development policies for FM. Congress has considered proposals which would require that all automobile radios have the capability of receiving FM broadcasts.(36) This is patterned after the UHF All-Channel Receiver Act and is designed to create a larger FM audience. It would certainly create a market for more FM receivers. The FCC has found that there is a "correlation between FM earning ability and the sale of FM automobile radios," since the prime advertising time on radio is the time of day that many people are in their automobiles going to or from work.(37) Interestingly, the same efforts at

development are being considered for FM as were tried for UHF television. Current organized consumer opposition to this policy indicates that potential political interest groups change over time and that what was achievable once may not be possible at another time.

FM Automobile Receivers Model. The interplay of the political forces involved in the FM automobile receiver decision is shown in Figure 4-8. Although the final decision on the requirement for FM in automobile radios has not been made, the strong opposition from a consumer group (labor union) appears to have had a significant impact on the outcome. This opposition has been effective in spite of the efforts by the FCC and established industry (set manufacturers and FM broadcasters). This example illustrates the potential effectiveness of organized consumer input to the allocation process and how it can affect the directions of technological development.

AM Broadcasting. The development of AM broadcasting technology has been much different from that of FM. The AM spectrum came into use when radio broadcasting first developed in the 1920's, so it has had a longer history.

It is evident from Figure 4-6 that there are more AM stations on the air than FM. In 1939 the AM spectrum was supposedly "saturated" and it was believed that it could absorb no more stations. Earlier, the Federal Radio Commission (the predecessor to the FCC) had taken 150 stations off the air in an effort to reduce the congestion.(2) However, since 1939, in exactly the same amount of spectrum bandwidth (1 MHz), the number of AM stations on the air has grown to six or eight times the 1939 number. There is no pre-engineered allocation table for AM. This means that the number of broadcasters is not fixed for a region ahead of time. Rather, depending on time of broadcast, antenna direction, and power, the same spectrum can

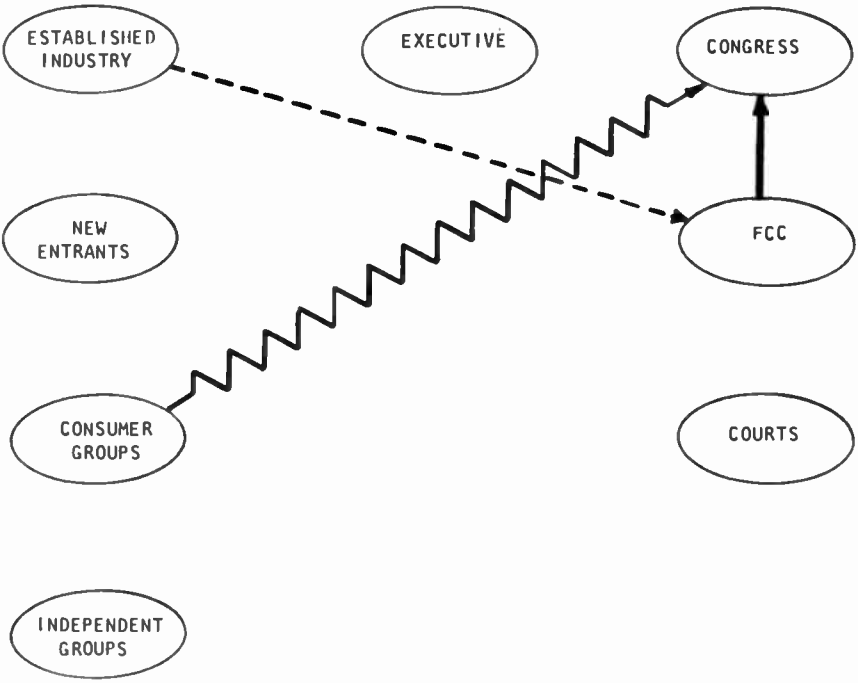

Figure 4-8 FM automobile receivers model

Established industries include FM equipment manufacturers and FM broadcasters, both of whom would gain from FM receiver requirements.

Consumer groups include both purchasers of automobiles and labor unions who oppose the imposition of costs of the receiver on the purchaser of automobiles.

The Federal Communications Commission is strongly advocating the adoption of the policy.

be occupied by a large, and unspecified number of stations. Licensing has been on an ad hoc basis. The congestion which this produces has given broadcasters incentives to develop new technologies to crowd more broadcasters into the same spectrum.(2) The overcrowding has largely been solved by the use of more sophisticated and more expensive directional antennas. This places the cost of technological development on the newcomers who seek to

wedge their way among existing, established AM broadcasters. The economics of AM radio indicate that small stations can survive in small communities, even with the kinds of technological expenses that such new entrants will incur.

In addition to new technological costs required to enter AM broadcasting, the FCC has imposed additional broadcast restrictions on new entrants. For example, the time of broadcasting is restricted so that the new stations do not impose too great an interference cost on established broadcasters. Also, in recent years the FCC has relaxed its technical standards to permit more interference among broadcasters than it used to allow. Interestingly, the FCC has also used licensing freezes to decrease the rate of AM station growth if not reduce the number of AM broadcasters on the air. The most recent freeze on new AM licenses was from July 1968 to April 1973.(37) The period of nearly five years did show a decrease in the growth of AM stations on the air. See Figure 4-6. The freeze did not, however, reduce the number of stations on the air.

Since the beginning, AM broadcast policy and development policy has been entirely ad hoc. Based on AM technology, the broadcasting industry gave rise to the need for regulatory intervention in the allocation of spectrum. These broadcasters preceded the FCC and for 50 years have been the established, broadcast industry. The lack of systematic policy in this area may be disconcerting to some, but the technological growth in AM suggests that for some kinds of development a congested spectrum may not be a significant deterent. Without a systematic set of policies by the regulatory agency, the AM spectrum has become heavily developed for commercial broadcasting. The AM spectrum has absorbed an increasingly larger number of broadcasters and has continued to attract audiences through low receiver costs and by specialized programming.

AM programming is specialized, but it lacks the high quality of FM reception. The programming tends to attract larger segments of the mobile population. Thus, popular music stations are numerous because of the potential market this kind of programming reaches. In some larger population centers, there are all-news and information stations, and in rural areas the stations can specialize in country and western music and programming. Not all segments of the listening population are satisfied by current AM programming. However, the segments of the audience which support such stations economically are provided with the programming desired. Part of the audience attraction for AM radio involves the inexpensive, easily-transportable radio. People who carry a receiver around with them, on their person, or in their automobile, provide a large part of the radio audience. This audience phenomenon might be called the "pocket-radio syndrome," but, by whatever name, the AM broadcasting industry has become economically viable on the basis of such audiences.

In addition to these considerations, it can be pointed out that the AM broadcast industry is a prime example of local programming and diversity. It is easy and economically feasible for many small communities to support such a radio station. This FCC objective for broadcasting may not be viable for the television industry yet, but, in terms of AM broadcasting, local diversity has been achieved.

The participants in the policy processes relating to radio broadcasting are similar in kind to those in television broadcasting. The broadcasters themselves are a central and potent interest. The new broadcasting entrant can be viewed as an outsider, who must dislodge the established operator to begin operation. However, the difficulty of dislodging the status quo depends on the portion of the spectrum involved and the amount of bandwidth which the new entrant requires. Thus, there

is room for more FM stations than currently are on the air, although a particular applicant may face an allocation plan that does not allow his station since that broadcast region is full. Despite the growth of AM stations, the only likely limitation on new entrants now would be another FCC licensing freeze or the lack of viable economic basis for the operation of the new station.

Equipment manufacturers are not directly involved in policymaking, although they may be major beneficiaries of a policy. This is especially the case when the equipment requires a new device (such as automobile FM receivers) which the purchaser must buy from the manufacturer. The consumer or listener groups may be emerging as more important and potent political, as well as economic, forces on current issues involving the imposition of direct costs for equipment or services.

The important policy parameters in radio broadcasting appear, in part, to be the level of signal quality possible and desired by the audience and the presence or absence of a pre-engineered allocation table. Had the FCC set the maximum number of AM broadcasting stations per listening area beforehand, and had it designated frequencies for them, the growth of AM would have been much different than it has been. While the resulting congestion would have been much less, the development of AM technology would have been much different. Whether this method (the allocation table) can or should be used to achieve technological development is an open question, but it appears that it can achieve some technology development by creating the incentive for developers to invest the time and other resources necessary to produce new technological devices.

Conclusions about Broadcast Technology and Regulation

The use of a technological device will depend on factors such as economic costs of the device and the benefits which it produces for the users. The regulatory climate in which the technology is set is as important as those economic factors. Certainly, there will be no demand for a device unless the regulator permits the use of it. Furthermore, the kinds of use permitted by the regulator are crucial to the development of the technology just as the permissable uses structure the economic viability of various industries built around the technology.

The regulatory parameters in which broadcast technology exists illustrate some of these points. For example, the degree and the precision of allocating a frequency may profoundly affect the development of a technology. If the allocation involves predetermined frequency designations as for TV and FM broadcast stations, there may be little need for intensive development of the spectrum arising from "congestion" in the spectrum. Another example of this is the choice of the color television broadcasting system for the United States. The FCC eventually chose the one which was compatible with the existing, 6 MHz bandwidth black and white system. There were several political reasons for the FCC choice--such as not to make obsolete the then existing television sets and not to bifurcate the audience into color and black-and-white viewers. A better quality color picture system was rejected, and the color technology developed around the alternate technological choice.

The present allocation plan for UHF television broadcast channels illustrates the protection of an industry and the resulting absence of technological incentives for alternative utilization of that portion of the spectrum. Under the FCC plan

1,098 assignments are possible. They are rather loosely packed within the allocated, 70-channel spectrum. Within the same 70 channels it is possible to make from 3,850 to 8,800 UHF channel assignments and still meet the current FCC technical standards for UHF broadcasting. These numbers may be surprising, but in comparison with the current 1,098 UHF assignments that have been designated, the actual number of UHF broadcasters on the air are even more surprising. The data in Figure 4-1 are only part of the numbers. There are 184 commercial UHF broadcasters and 149 educational UHF broadcasters in operation, a total of 333 in comparison with the 1,098 FCC (30 percent) designations and the technically possible 3,850 (8 percent) or 8,800 (3 percent) channel assignments.

The efforts to create artificial markets for UHF broadcasters by requiring UHF tuner capabilities and limiting cable television in various UHF viewing markets have not resulted in the policy objectives of local broadcasters, diverse programming, and "full" use of the designated portions of the spectrum. In contrast, the demands by alternative users of the UHF spectrum have mounted in recent years. The UHF technology has neither had to develop in the face of increased congestion nor has the UHF broadcasting industry developed into a viable enterprise.

In contrast to this, the AM radio spectrum has accommodated increasing numbers of broadcasters, and these in turn have served increasing numbers of receivers. The spectrum congestion which resulted from the regulator's ad hoc approach to license assignments has produced a variety of technological devices to permit more broadcasters to use the spectrum. A number of small, local AM broadcasters are able to provide adequate local advertising and programming and are economically viable.

The regulatory arena which structures the development of broadcasting technology is largely defined by the participants who are involved in the regulatory and the allocation process. The allocation of the scarce resource of spectrum is the heart of the political process which determines the development and use of these technologies. The Federal Communications Commission, a known arena in which the participants can interact, handles this process which largely revolves around who is assessed the costs of the allocations and the acceptance of these costs and benefits by the participants who benefit from spectrum usage. The efforts to create demand for UHF TV spectrum allocations among potential broadcasters through requiring receiver capability illustrate the most open effort at technological incentives through allocation. To date, these efforts have not achieved the desired results from the regulator's or policy maker's perspectives. However, certain groups have benefited, such as the UHF tuner industry. The failure to enact a statute requiring FM tuners in automobiles may simply be explained by potent, counter pressure from consumer groups who would have to pay the costs. Such pressure was not present when the UHF All-Channel Act was proposed and enacted over a decade earlier.

The technology associated with CATV systems presents a picture of technology waiting for the appropriate political and regulatory climate. The technology has been available for some years. It could develop rapidly and dramatically from its present state but will not unless there are economic incentives for that growth. The economic demand for advanced cable technology depends on the regulatory policies of the FCC. Such demand also depends on entry into the large markets, and that entry is controlled by the established broadcasters and the commission. Until the broadcasting interests, with program producers, are willing to

accept significant entry into these viewing markets by CATV systems, cable technology will develop very little. The current FCC regulations which require certain channel capacities and two-way capability, are little more than window dressing in terms of technology. The economic constraints on cable development will be controlling as long as the regulatory agency and established interests impose markets constraints on CATV.

The entire regulatory scheme in this industry is premised on a variety of imperfections in the operation of the free market system which economists and entrepreneurs use for analysis. Regulation is an effort to interject certain controls to prevent the development of undesired economic effects which are associated with monopolies. One of the current problems with regulation of industry by the government is that the regulation may produce a variety of undesirable side effects of its own. One of those is alleged to be protection of the regulated industry from competitive entrants. In the case of CATV, this protection of the established broadcasters seems to be quite evident in the 1972 CATV regulations. The UHF allocation system shows the effects of closing off a portion of the spectrum to certain alternative uses in an effort to encourage other, apparently more desired, uses. The AM broadcasting industry, however, illustrates the technological results when some element of open entry is permitted. That result may or may not be desirable. However, this setting does have different technological results from the closed-entry, regulatory effort.

Chapter 5

Two-Way Telecommunications

Importance of Two-Way Telecommunications

Just as radio and television strongly affected the social structure of the United States so also did the telephone. Radio and TV introduced national product advertising, new entertainment sources, and new means for influencing public opinion. The telephone produced an enormous impact by radically altering the methods and greatly increasing the speed of carrying out commercial transactions and in changing the nature and scale of direct interpersonal telecommunication. All of the industrially developed countries of the world felt the impact of the telephone.

Other means of two-way communication, besides the conventional telephone, are also vital to today's world. Two-way radio, one of the most important, is used for ship-to-shore communication, police and emergency communication, aircraft communication and control, dispatching of commercial vehicles such as taxicabs and trucks, and a wide range of military applications. The development of radio prior to World War I completely altered naval tactics when it became possible for ships to communicate with each other in darkness and over the horizon. This revolution in tactics has progressed until now virtually all military operations are based on continuous two-way communications with command centers.

In recent years a new type of communication has become increasingly important. This is the com-

munication of data as opposed to verbal information. The accumulation and analysis of data have always been of great importance in operating government and commercial enterprises. However, with the recent advent of the computer as a vital link in the day-to-day operation of organizations and businesses, the need for more rapid interchange of data has greatly increased. Today, vast networks are planned specifically to transmit information to and from computers, and the volume of such communications will increase for many years to come.

Over the years introduction of new technology to expand or improve two-way communication capabilities has continued. Perhaps the most dramatic, recent technological innovations have been the communication satellites and the video telephone both of which truly represent the integrated circuit society. Of the two, the communication satellite has been an unqualified success while the other did not even get so far as a full-scale trial. Later sections of this chapter explore the reasons for this dichotomy of results.

Other less dramatic, though equally important, developments have also been evolving in the past two decades. Among them are the introduction of new switching systems, the development of new data transmission techniques and systems, the opening up of the switched telephone system for attachment of devices other than telephones, and the provision of a variety of new services such as dial up remote terminal connection to centrally-located general-purpose digital computers. Enormous progress has been made in many areas of two-way telecommunications and these developments have had a profound impact on society in all aspects of its structure and operation.

While these revolutionary developments have been occurring in many areas of telecommunications technology, other areas have not undergone such development. Frequently, already available technology

has not been incorporated into existing systems in a timely manner. Why do we not have an effective mobile telephone capability? Or why is there great disparity in the effectiveness of the switching system technology used in various countries of the world and even within individual countries? Why has citizen's band radio become the most rapidly growing radio service in the United States but appears to be operating without enforcement of the regulations established to prevent its abuse and its interference with other services?(1) These and other questions concerning the forces that determine the support for development and adoption of new technology are examined in the following sections of this chapter.

Growth of Two-Way Telecommunications

Before considering case studies relating to specific examples of development and usage of two-way communications technology, perspective can be gained by considering the rate of growth and the scale of present utilization of two-way communication media. A convenient vehicle for this purpose is the switched telephone system, both in the United States and in other countries. Figure 5-1 shows the growth of various telephone services in the United States over the past two decades. By 1974 the telephone system in the United States represented an investment in excess of $80 billion and was still growing at a substantial rate of more than $8 billion per year. While services were expanding, the real costs of using those services were going down as the economies of scale became effective. Figure 5-2 shows the charges for long distance calls from New York to Tokyo, London, San Francisco, and Philadelphia. The costs have been referred to the 1974 dollar by dividing the actual charges by the ratio of the commodity price index for each year to that of 1974. It is evident from

this figure that the greater the distance between cities called, the greater the reduction in costs that has occurred.

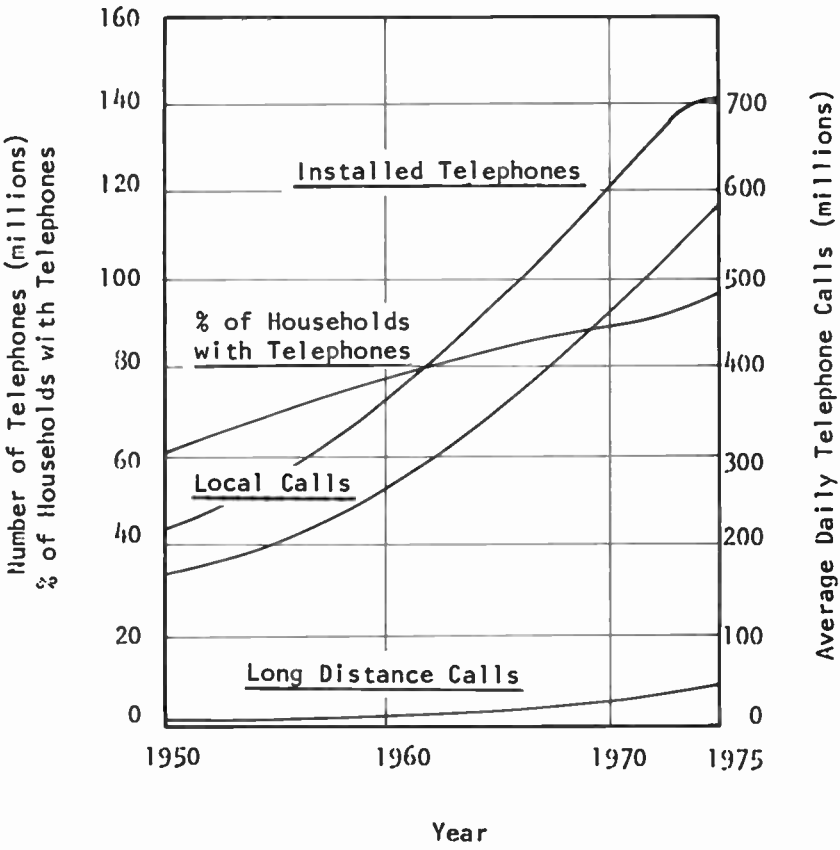

Figure 5-1 Growth of telephone services in the United States. Source: *Statistical Abstract of U.S. 1976*.

Elsewhere in the world, telephone installation and utilization has also increased. Figure 5-3 shows the number of telephones installed per 1000 population for the eight largest telephone users.

Clearly, there is a continuing upswing in telephone availability throughout the industrial nations. In none of the large countries does any saturation of the market appear. Many cities, such as Washington, D.C., actually have more telephones than people.

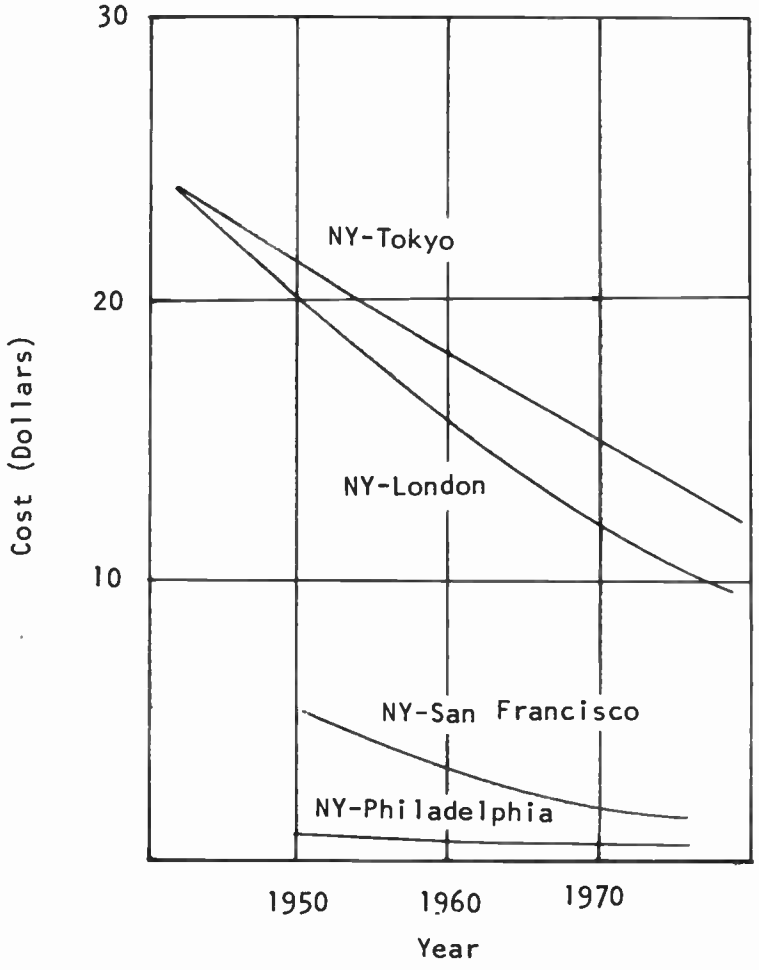

Figure 5-2 Long distance telephone charges adjusted to 1974 constant dollars. Source: *Statistical Abstract of U.S. 1976*.

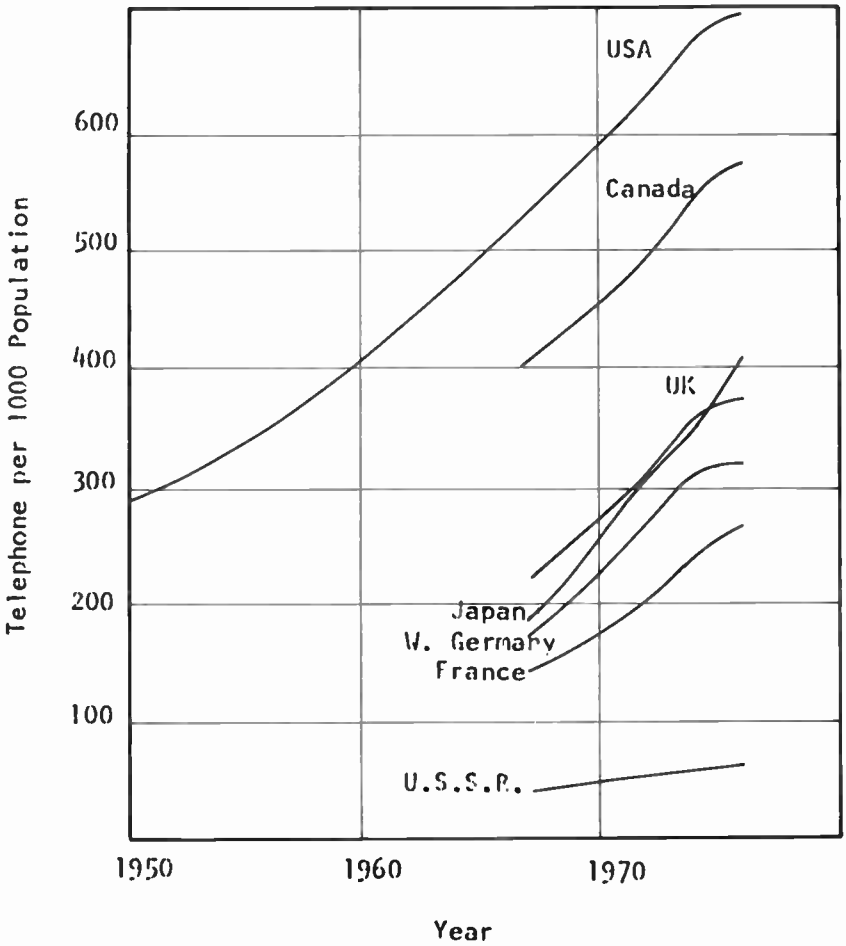

Figure 5-3 Telephones per 1,000 population. Source: *American Telephone and Telegraph Co.: The Worlds Telephones, 1961-1971.*

Other statistics regarding two-way radio communication or data transmission would show similar strong growth trends. Undoubtedly, the availability and usage of two-way telecommunications is becoming more and more pervasive in world societies.

The effects of this phenomenon will probably be felt for generations to come and could well alter future world social, economic, and political structures. If so, then it is important to inquire into how the rapid evolution of technological services and methodologies is being controlled and directed toward some set of socially acceptable and desirable goals.

A first reaction to looking at the advances in telecommunication technology is to marvel at the revolutionary developments that are occurring. Many people take it for granted that such advances are the natural outgrowth of well-ordered industrial research programs and that they find their way into usage under control of social and economic forces that tend, in general, toward promoting the "common good." Unfortunately, this view is far from the truth and completely ignores some of the most important forces that are shaping the technological, economic, and social character of telecommunications developments.

Conventional economic factors such as basic scientific and engineering knowledge, available capital, and customer demand are necessary for successful development and marketing of new products or services. However, particularly in two-way telecommunications, political decisions play an equally and oftentimes greater role in determining the course of technological developments. The political climate and the political arena of society strongly influence how, when, and, frequently, in what directions new technological developments will occur. Often there is little relation between what is technologically feasible and what the political climate will permit. This aspect of technological development will be detailed in specific case studies and in the following discussions of the regulatory process by which telecommunications are controlled in the United States. The complex interplay of the various forces affecting telecom-

munications development will be clear. A subsequent chapter will consider alternative means of controlling the result of these forces as a way of approaching a regulatory process serving the "common interest."

The Regulatory Setting

Common Carrier Political Arena

Regulation of common carriers is closely related to regulation of the radio spectrum, except that the participants and the issues differ. The Federal Communications Commission is the principal arena in which the decisions are made, although some participants in certain cases have used the courts and the legislature. The actors include the established common carriers such as AT&T and the other telephone companies. Any new entrants are either equipment manufacturers (other than Western Electric, AT&T's equipment affiliate) or small companies that propose to offer a service for which they seek FCC approval. The new entrants are often specialized carriers, who seek to provide a particular service to all comers. They may be established firms which are expanding or branching off into new areas, or they are new companies just starting up with the proposed service as their only product. The service users, the customers of the common carriers, seem to be more active in the regulatory process than in the broadcast area. (Two-way communication does require a less passive role for the users.) At least some users, and nearly everyone in the nation uses the telephone system to some extent, have been quite vociferous, and sometimes successful, in achieving a policy result beneficial to themselves.

Natural Monopoly

The telecommunications industry has been regulated by various agencies of the federal government and

some state governments for most of the 20th Century.(2) Interstate telephone rate regulations began in 1910 when Congress enacted a statute giving the Interstate Commerce Commission authority to approve such rates. The regulatory arena shifted to the FCC after the enactment of the Communications Act of 1934.(3) However, the basic reason for regulation, market failure, has not changed much. That is, since the market pricing system does not provide an optimal distribution of goods and services, government has made an extensive effort to inject economic constraints to produce results comparable, in some respect, to a market situation. The natural monopoly, the *raison d'etre* for most regulation, is based on the economic fact that in some industries economies of scale permit a single supplier to provide complete service at the lowest price to customers.(4) In such a "monopoly" situation, the regulator is charged with protecting the "public interest" by preventing monopoly profits yet allowing the monopoly to provide its services at a profit. A variety of economic problems surround the existence and even the definition of a natural monopoly, and these problems must be addressed by the agency in order to achieve regulation in the "public interest."(5) The two-way communication system in this country has developed as a regulated industry. Federal, state, and local government agencies all have received regulatory authority on the basis of natural monopoly arguments.

The regulation of the telecommunication industry in this area is largely rate regulation rather than service regulation. The common carrier concept is based on a natural monopoly which offers service to all customers without regard to content, so long as the customer pays the allowable rate. It depends largely on regulatory control of the rate of return which these carriers can make on their capital investment. Rate-of-return regulation involves com-

plex considerations relating to what capital items the carrier should be allowed to include in its base--the rate base upon which the rate of return is calculated. Within the past 10 years the FCC has begun to re-examine its basic guiding philosophy regarding the common carrier telephone companies in the country and to pursue policies designed to achieve regulatory ends, by means not generally accepted among the regulated industries.

Competition

Case studies in this chapter offer some recent examples of regulation in the telephone industry, which contain an element of competition. The FCC has made several decisions regarding competitive entry into certain telephone services, which indicate that the commission may be trying to inject some competition into the two-way communication market for a variety of unarticulated or unclear reasons. The emphasis of these decisions has been to permit limited, rather than full-scale, competition from new entrants for certain kinds of services for which the common carriers had enjoyed a protected market under the traditional regulatory climate since 1934. Common carriers have met this competitive element with a variety of tactics. (See Appendix for the text of the "Bell Bill" proposal, designed to protect the natural monopoly of common carriers.)

The competition which has appeared recently is of two kinds.

In the first, which is traditional, new entrants offer service where there is an unanswered demand. These new entrants are much smaller than the common carrier telephone companies, dominated by Bell, the world's largest telephone company, which has 87 percent of the telephone market and nearly all the long-lines traffic in the country. Usually, the new entrants propose to provide a new, but limited, service which the telephone carriers are

either not providing or are providing at a rate much higher than the proponents suggest.

The second kind of competition arises from the use of alternative technologies by competitors. The rapid development of alternative technologies which can provide a particular service, let competitors take advantage of cost savings, or improved transmission techniques. This is clearly an issue with undersea cables and satellites, and land microwave systems and satellites. These cases will be discussed later in this chapter. Technological changes, rapid recently in the telecommunications industry, present particular opportunities and problems for this competitive setting. The FCC is investigating the implications of competition in the telecommunications industry with a fact-finding proceeding.(6)

The issues that arise in this area of regulation relate largely to the rates which the commission permits the common carriers to charge for various services. This complex issue has a long history, but it can be summarized by saying that the commission has permitted, even required, the carriers to use an average, per-mile rate for many of its services. Thus, without regard to the particular costs the carrier encounters in providing a particular service, the rate for that service will be uniform for equal distances. This permits cross-subsidization of services. In the heavily used portions of the system, the rate is much higher than the cost of the service. However, these high rates subsidize the high-cost, low-use portions of the system. New entrants providing various services can underprice the common carriers by charging the cost of the service, rather than an average for a nationwide system. This raises economic and political issues for the common carriers and new entrants about the costs of service and the rate of return. In addition to the issue of rates, there can be issues about the services provided and those de-

manded of the carriers. New entrants may try to provide a service which the common carrier is not supplying and for which the new entrant finds a demand. The debate over services is illustrated by several of the cases discussed in this chapter.

Technology and Regulation

There is an important set of relationships between technology and regulation. Regulation frequently involves control of technological development. Various theories, some with empirical support, suggest the fashion in which a regulated industry will develop technology and innovate new technologies.(7, 8) These theories generally point to the prospect that an established carrier will use the already existing technology, in which it has already made major capital investment, until the investment in the technology is fully amortized and depreciated. The problem with this strategy, from the perspective of technological innovation is that the amortization of these technologies is spread over long periods ranging from 20 to 40 years. In this industry, where a new technological development can appear at any time, and they appear more rapidly than once in 30 years, the old technology will not be replaced nearly as fast as is possible. Telecommunications is capital intensive, which means that the physical plant requires great capital before any service can be provided or any revenue is received for the service. The regulatory policy determines the company's revenue on the rate base, which is a fixed percentage return on the investment by the carrier. Thus, the carrier has an economic incentive to invest as much money as possible in plant and other rate-base items, so that the fixed rate of return will produce the greatest amount of revenue. Coupled with the capital intensive nature of the industry this incentive may retard the adoption of a new technology or a cheaper technology.

The development and adoption of a new technology would be based on market mechanisms if there was no regulation to contend with. Under this scheme, the cheapest, most efficient technology would be used for a service and would be replaced when a cheaper and more efficient technology was available. Given the protected position of the regulated industry and the capital incentives to choose the most costly technology, the innovation rate within the telecommunications industry may be slower than in a free-market setting.(8) The actual rate of innovation and adoption is difficult to determine, and the evidence of innovation in telecommunications is mixed on this important point. However, it is important to remember that the rate of adoption and the direction of technological development depend in part on the regulatory climate in which the industry must operate.

Communication Satellites

The first serious suggestion that satellites in geosynchronous orbits (i.e., stationary above a specific point on the earth's surface) be used for two-way telecommunications was made by Arthur Clarke, a British engineer, in 1945.(9) He envisioned a satellite orbiting the earth at exactly the correct altitude (42,000 km or 22,300 miles) so that its period would be precisely 24 hours and it would therefore appear stationary above the same spot on the earth's surface. Unlike other heavenly bodies it would neither rise nor set but would remain fixed in the sky. By providing receiving and transmitting equipment on board the satellite, it could act as a relay or repeater between points on the earth that were out of line-of-sight contact with each other but were each able to "see" the satellite. Clarke envisioned the satellite providing a vast array of services. Among them were telephone, radio, television, and postal services.

He even proposed that individuals be able to utilize the relaying capability of the satellite directly through their own private antenna systems and appropriate transmitting and receiving equipment.

Much of Arthur Clarke's vision has come true but many years have elapsed since it was first proposed as a technologically feasible advance in telecommunications technology. Why was there such a long time interval between proposal and actual development of telecommunication satellites? By what route was this development actually carried out and what societal forces have affected this development? What impact have communication satellites had on society? These questions are the subject of this section.

Satellite Technology Development.(10, 11, 12) The launching of the Russian Sputnik I on October 4, 1957, ushered in the era of the satellite. Until then the pace of satellite development in the United States had been slow. As part of a worldwide scientific program, the United States had agreed to launch an artificial satellite; however, the launch vehicle development was being carried out on a low-budget program independent of the military rocket development program. The orbiting of Sputnik, eerily beeping from outer space, provided a new impetus that catapulted the United States into a space race ultimately leading to successful landings on the moon. Along the way, however, a whole array of communication satellite technology was developed that has had a marked effect on the kinds and costs of two-way telecommunications services that are available now and that are likely to be available for decades.

The U.S. first conducted communication experiments with artificial earth satellites in 1960 as part of the ECHO project. This was a joint program of the National Aeronautics and Space Administration (NASA), the Jet Propulsion Laboratory of the

California Institute of Technology, and the Bell Laboratories. It utilized a large metalized balloon that served as a passive reflector. Radio waves were bounced off the satellite's surface allowing transmission between widely separated points. Although the use of passive satellites has many attractive features, its major drawback was the elaborate ground station equipment required to get a sufficient signal-to-noise ratio to permit efficient communications. The received signal strength is reduced proportionately to the fourth power of the distance for passive satellite communication as compared with the square of the distance for active satellites. As soon as suitable space-qualified power sources and attitude stabilization systems became available, all experiments with passive reflecting satellites were dropped.

There were other drawbacks. The rockets used to launch early satellites could place only relatively modest payloads into earth orbit. Typical orbits were on the order of 150 km (93 miles) above the earth's surface and had orbital periods of about 90 minutes. Such satellites were not completely out of the earth's atmosphere and therefore were subject to drag that shortened their useful lives. Because of the rapid rate at which such satellites move overhead, it is necessary to track them electronically and to have a new satellite come over the horizon before the previous one has disappeared from sight. Experiments by AT&T with the TELSTAR (1962-63) and RELAY (1962-64) satellites proved the feasibility of active satellites at low and medium altitudes, and communication systems based on as many as 50 orbiting spacecraft were proposed for operational purposes.

For a variety of technical and political reasons, the low altitude satellite system that AT&T proposed was not adopted in the early 1960's. In fact, an act of Congress excluded AT&T from directly participating in the development of satellites for

transoceanic communication, giving sole responsibility for such developments to a new company, the Communications Satellite Corporation (COMSAT).(13) Under the direction of COMSAT, the emphasis moved from low altitude satellites to the geosynchronous orbit proposed by Clarke in 1945. Achieving and maintaining satellites in such orbits proved to be a substantial technical challenge. However, successful launches as part of the SYNCOM series in July 1963 and August 1964 established their feasibility. Great sophistication of the control and station-keeping operations both on the ground and in the spacecraft are required to achieve and maintain a geosynchronous orbit in the presence of the many disturbances ranging from solar winds to gravitational perturbations due to the moon and the planets. These problems have been solved and today the geosynchronous orbit is a state-of-the-art capability.

In 1964 the International Satellite Communications Consortium was formed by 14 nations interested in seeing that the development of international communication satellites was carried out expeditiously. The United States' representative to the international group was COMSAT. The first commercial operational communications satellite was launched from Cape Kennedy on April 6, 1965, and was placed in geosynchronous orbit over the Atlantic Ocean to provide communications between Europe and North America. This was INTELSAT I which provided 240 two-way-voice circuits. This satellite was followed by similar satellites: INTELSAT II in 1967 also having 240-voice circuits but with increased signal power; INTELSAT III in 1968 having 1,200-voice circuits; and by INTELSAT IV in 1971 having 5,000-voice circuits. The satellite configuration proposed for 1980 has a 25,000- to 50,000-voice-circuit capacity.(10) Four operational and four spare satellites of the INTELSAT IV series are in orbit. Two are over the Atlantic Ocean, one

over the Pacific Ocean, and one over the Indian Ocean. The earth portion of the INTELSAT system consists of 150 stations in 80 countries. The global nature of the INTELSAT system is shown in Figure 5-4.

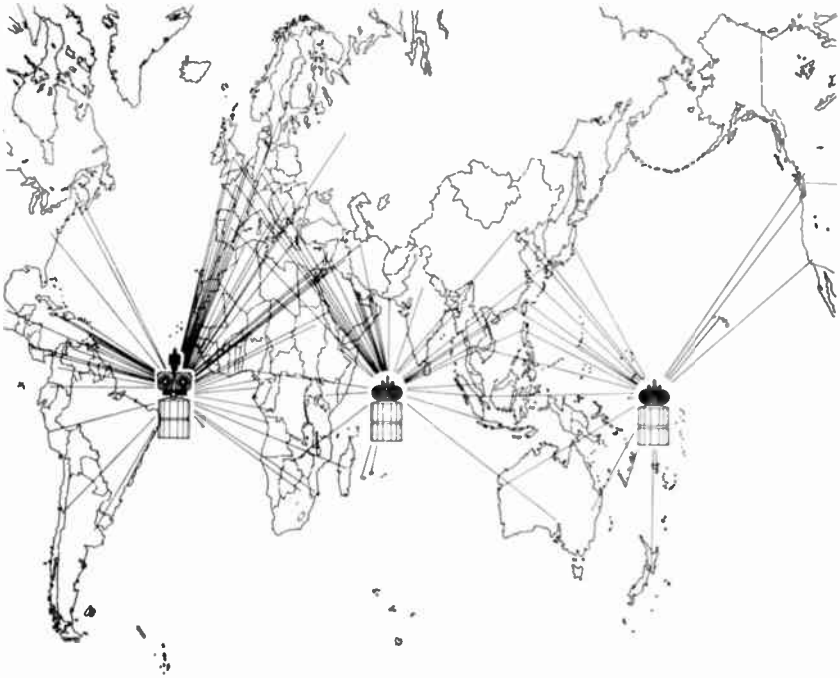

Figure 5-4 INTELSAT global system. *Science Magazine* photo.

The early INTELSAT series satellites were limited in channel capacity primarily by power, i.e., they were not able to transmit simultaneously on all of the channels that were theoretically possible with their system bandwidth. For example, the INTELSAT III satellite with a system bandwidth of 450 MHz had a 1,200-voice-circuit capacity, whereas the INTELSAT IV satellite, with a system bandwidth of 500 MHz, was able to achieve a 5,000-

voice-circuit capacity because it had six times the power of INTELSAT III. The INTELSAT IV is the first of the systems that is bandwidth limited rather than power limited.

Transmission to the satellites from earth is in the 6 GHz frequency band and from the satellites to earth in the 4 GHz band. Only 500 MHz of bandwidth is allocated in this portion of the spectrum for satellite communications, and, therefore, further increases in circuit capacity will require use of new technology such as polarization diversity (which can double the capacity) or higher frequencies of transmission where more bandwidth is available. The INTELSAT IV has a spot coverage capability, using a steerable, directional transmitting antenna, as well as a global coverage capability. Depending on the division of power between the spot and global coverage antennas and the particular kind of modulation used, the circuit capacity can vary from 3,000- to 9,000-voice circuits or equivalently 12 television channels. This satellite also has the capability of communicating with small earth terminals having antennas of 5 to 10 meters (16 to 33 feet) in diameter, and thus provides the potential for new services not yet being exploited.

Two other communication satellite developments are of considerable, current interest. They are the domestic communication satellites and an experimental services satellite, the ATS-6, that is demonstrating new potentials for satellite communication.

The first domestic satellite system to be placed into operation was TELSAT-Canada's ANIK 1 which was launched on November 9, 1972, and followed by ANIK 2 launched on April 20, 1973. In 1974 Western Union placed two WESTAR satellites in orbit. These four satellites are all similar in design and each provides approximately 7,000-voice channels or 12 color television channels. Two new systems, each utilizing three satellites, are being put into

operation by RCA Globecom and by AT&T and GTE Satellite Corporation. The initial satellites were launched in 1976 and employ polarization diversity to double their circuit capacity to 14,000-voice channels each. European domestic satellite development is proceeding but lags well behind that over the North American continent. In the late 1960's Russia deployed a satellite communication system based on low altitude (i.e., nonsynchronous orbit) satellites known as the MOLNIYA series. Not until 1974 did the USSR launch its first synchronous orbit communications satellite.

The rate of growth of available satellite voice circuit capacity has been spectacular, going from 240 in 1965 to over 50,000 in 1975. At the same time the investment cost per circuit per year for the INTELSAT IV is $1,000 and that for the next generation of satellite (1980) will be $100.(10) The cost and availability of long distance transmission facilities is no longer the primary constraint on expanded two-way telecommunications.

Applications Technology Satellite. On May 30, 1974 the Applications Technology Satellite (ATS-6) was launched from Kennedy Space Center and was placed in a geosynchronous orbit. This satellite differed from earlier spacecraft philosophy which had been directed toward minimum weight and maximum reliability in the spacecraft system.(14) In the ATS-6 the design philosophy was to incorporate sufficient sophistication into the spacecraft system so that low-cost, simplified ground terminals could be used to communicate to and from the satellite. The key feature of the ATS-6 is a 9.1-meter (30-foot) steerable antenna which provides adequate gain so that ground terminals with a 3-meter (10-foot) antenna can receive direct broadcasts of high quality color television signals. Also, the satellite was designed so that it could be moved to more than one geosynchronous orbit.

Initially, the ATS-6 was placed in orbit to serve North America including Alaska. A number of

experiments were carried out during the first year to investigate the feasibility of relaying programs through the satellite directly to such facilities as schools, CATV systems, and clinics.(15) The overall telecommunications system to support these experiments included 120 video receive-only terminals, 51 radiotelephone transceivers, and eight video originating terminals. Very promising results were achieved in all experimental programs ranging from transmission of education programs for rural schools in the United States Appalachian region to small medical clinics transmitting diagnostic video in the Alaskan bush to a hospital in Fairbanks. In May 1975 the satellite was moved to a new orbit where it began providing direct television broadcasts to rural villages in India as part of a further experiment in providing educational opportunities to regions having inadequate telecommunication facilities.

The experiments carried out with the ATS-6, the world's most powerful and versatile communications satellite may well herald a new era of technological aid to education, medical, and telecommunications services.

Political Arena of Communication Satellite Development

In the pre-1962 years, some government officials and private citizens were concerned about how the United States would develop and use satellite technology. At that time only the Soviet Union and the United States were capable of launching artificial satellites. Some private companies such as AT&T were active in research and system planning of satellite communication systems and were considerably set back by enactment of the Communication Satellite Act of 1962.(13) In his recommendations to Congress regarding satellite communications, President Kennedy specified that to promote international cooperation and to insure open and equitable access to such communications facilities, a single corpo-

ration should be created. The law produced the Communications Satellite Corporation (COMSAT), and gave it a unique position in communications.(16)

COMSAT was required to offer half its stock to the public and the remainder to U.S. companies engaged in international communications. This meant that the companies, which stood to lose the most from the creation of a new entrant, received ownership as an economic incentive for supporting its development. COMSAT was to have exclusive control over the launching and use of U.S. communications satellites that would be used for international communications. Interestingly, the initial view of satellite technology was that its only practical uses would be for *international* communication. Clearly, from the 1962 act, everyone understood that COMSAT's control would only reach to the international dimension of such communication. Besides permitting the international carriers to purchase 50 percent of the stock in the new company, they were also allowed to appoint six of the 15 members of COMSAT's board of directors while the public owners appointed six and the President appointed three. This meant that the communications companies (largely AT&T) would have a major voice in the policy decisions of the corporation. This created some conflict-of-interest questions which were solved only by FCC ruling that COMSAT could only serve the carriers and not compete with them for service to users.(17) COMSAT thus became a carrier's carrier.

The technology implications of the 1962 statute are highly significant. The new corporation was not expected to develop the technology required. However, the legislative history indicates that COMSAT was to encourage technological development through its acquisition of equipment for its systems and thereby provide hardware developers with incentives to remain in the field. Major developers and manufacturers would have no significant

role in the development of satellite technology unless they were able to obtain a contract from COMSAT to produce such equipment or systems. Furthermore, the selection of the particular technology to be utilized was COMSAT's responsibility. An example of this was the choice of the geostationary orbit system over the random orbit, low altitude system AT&T strongly supported.

The act also created an interesting set of problems because the international carriers such as AT&T and ITT could own or participate in the ownership of undersea cables while they were prohibited from owning the satellites. Interestingly, many major advances in undersea cable technology came in the mid 1950's just before satellites became a reality, and the international carriers began making major capital investments in such cables from the outset. Technologically, satellites will unquestionably surpass cables in circuit capacity, switching capabilities, and, with the exception of transmission delay, quality of service. A study by the National Academy of Engineering has estimated that for systems of up to 720-voice circuits satellites and cables are economically competitive but that for large systems the satellite system is likely to be one or more orders of magnitude less expensive on an investment-per-circuit-per-year basis.(18) However, at present they are in close equivalence for many types of service, and a potentially competitive situation between the two has developed.

Competition is completely controlled by the FCC which licenses transoceanic cables, as well as satellites. The effects of this regulation may not be economically optimal, since the FCC has tried to satisfy both sides of this effort by licensing both facilities, sometimes permitting substantial duplication of services. For example, the FCC licensed a new 720-voice-circuit cable from Florida to the Virgin Islands in 1966. During the same year, the

FCC approved the building of a communication satellite earth station in Puerto Rico. Both the satellites and cable interests supported *both* services even though one or the other of the systems would appear to be redundant. The FCC stipulated that since the then current demand for service would not support both systems, the new traffic was to be allocated 50/50 between the satellite and cable circuits.(19) The reasons for this allocation appear to be more political than economic or technological.

While domestic satellites were initially seen as unlikely, subsequent technical developments have caused the emergence of domestic communications satellites as a major, current regulatory issue. The FCC began inquiring into the development of domestic satellites in 1966, and only recently has it reached a final policy outline for allocations.(20) The current technology is well advanced and provides for attractive switching and circuit features. Furthermore, it is clear that domestic satellites will compete economically with a number of services currently being supplied by other means.

Technopolitics of Communication Satellites

The politics of domestic communication satellite development involved interests which sought either an open-entry policy by the government, which posits marketplace competition, or a regulated industry policy, which would restrict entry. The play of political forces in this contest illustrates much about the technopolitics concept. In the early 1960's, the President (Kennedy) strongly supported a fully controlled satellite program. In the mid 1960's, the President (Johnson) and his task force did not support any particular policy because of many unanswered technological and economic questions.(21) However, in 1972, the President (Nixon) supported an open-entry policy, and the chairman of the FCC (Burch) also favored such an open-entry policy.(20) COMSAT and the FCC staff

supported a controlled-entry policy, and there was some Congressional support for this. The final result is that the FCC is operating currently with an open-entry policy, licensing competing systems as they are proposed. This may produce significant changes in the development of communication satellite technology. New companies, new system requirements, and new technology will enter the field. TELSAT Canada, Western Union, and AT&T-GTE have already placed operational satellites in orbit; and a consortium headed by IBM is seeking entry into the field in the near future. It appears probable that significant advances in technology and services will occur as a result of this competitive setting for domestic satellite system development.

The past 12 years of political developments in the satellite communications area illustrate different effects of political control on development of telecommunications technology. The conclusions are intriguing although not altogether definitive. The political alliances change over time. The alliances also change as the economic scene changes. Thus, the private carriers took a much different tack after the enactment of the statute in 1962 with regard to communication satellites. However, the current domestic satellite picture seems to be economically quite encouraging for them, and they are active in a variety of governmental arenas seeking to utilize their political advantages to insure their technical position in this newly emerging segment of the communications industry.

The alliances also depend on who the particular office holders are, as in the case of three presidents (Kennedy, Johnson, and Nixon) pursuing widely differing policies on related matters in the course of 10 years. The Federal Communications Commission appears to be caught in the middle of much of the decision making process--forced to contend with diverse interests and conditions and apparently trying to give something to each interest in each set of circumstances.

The technopolitical model of the COMSAT decision is shown in Figure 5-5. The principal participants are the new entrants (international carriers), the Executive, and Congress. The new entrants were resisting the closed-entry policy that ultimately prevailed while the Executive supported this policy. The final allocation was made by Congress when it passed the Satellite Communications Act of 1962. The principal result was to concentrate responsibility for technological development in a single organization, COMSAT.

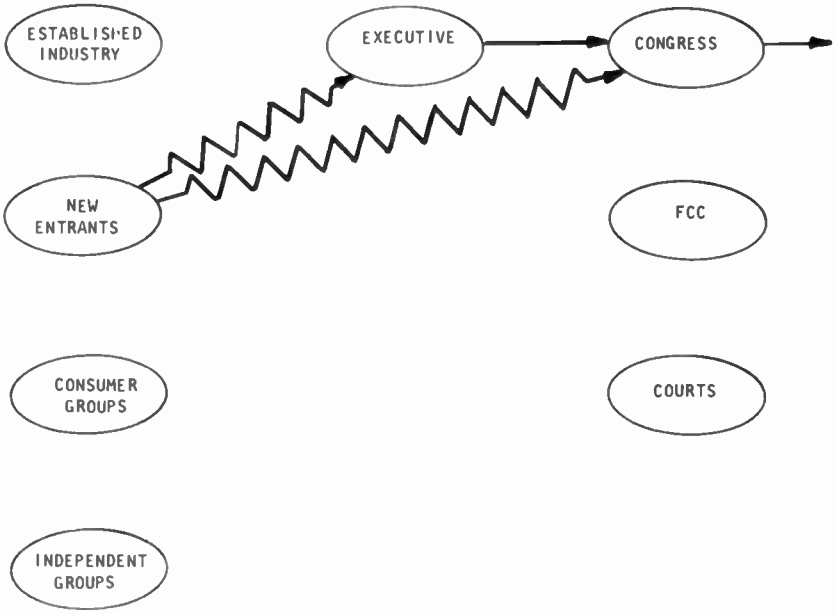

Figure 5-5 COMSAT allocation model

New entrants include the established common carriers seeking entry into the ownership and operation of communications satellite facilities.

The model for the domestic satellite decision (DOMSAT), Figure 5-6, is substantially different than that for COMSAT. Here the established in-

dustry (COMSAT) opposed what turned out to be the eventual policy while the new entrants (common and special carriers) and an independent group (Ford Foundation) supported it. Congress took no firm position, and, therefore, the policy of open-entry proposed by the Executive prevailed. The result of this allocation process was to introduce significant competition into the technology and service aspects of domestic satellite system development.

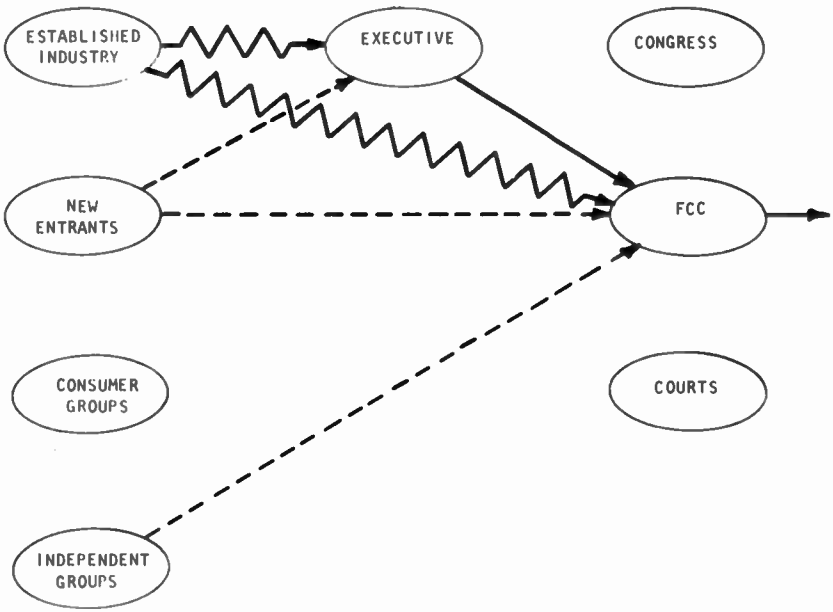

Figure 5-6 DOMSAT allocation model

Established industries include the established common carriers, particularly COMSAT, who sought to restrict entry into domestic communications satellite to those experienced carriers.

New entrants include Western Union, ITT, IBM, and RCA who sought entry into the domestic satellite business.

Independent groups include the Ford Foundation which sought to foster open competition.

The Executive also sought to foster an open competition policy for domestic communications satellites.

Foreign Attachments and Carterfone

The Bell Telephone system has long had a policy of discouraging interconnections with nontelephone systems and with non-Bell telephone devices. The refusal of Bell to interconnect with other telephone companies in the early decades of this century led to anti-trust charges and litigation which ended in the Kingsbury Commitment of 1913 after which Bell willingly interconnected with competing telephone systems to avert possible antitrust action by the government.(5) In addition, Bell has long been able to prevent the attachment of foreign devices to its telephone system, by requiring that anyone who has a Bell telephone agree not to make such attachments.(22) Bell reserved the right to disconnect or remove any such devices if they were attached by a telephone user.

This policy did not prevent manufacturers of equipment from developing and selling various devices to be attached to phones in order that the user could enjoy a service or advantage which the telephone system itself did not provide. The FCC, through the *Hush-A-Phone* decision in 1955, upheld Bell's prohibition of foreign attachments.(22) Bell's argument for such authority rested largely on the need to maintain the integrity of the telephone system, which Bell claimed it could not do if various, non-Bell devices were tied into the system. Bell argued that they were responsible for the quality of the service to their customers, and they could not guarantee that quality if such devices were permitted on their phone lines. The Federal Court of Appeals reversed the FCC on this decision, and that resulted in the first crack in the otherwise complete prohibition against such foreign attachments.(24) The Bell companies interpreted the decision as narrowly as possible, and generally refused to interconnect after that.(5)

The second major effort to achieve interconnection for foreign attachments was successful,

when in 1968 the FCC held in *Carterfone*, that the Bell system had to allow interconnection, as long as the integrity and quality of the operating system was maintained.(24) (See Appendix). Thus the Bell system filed new tariffs with the FCC listing the charges for such attachments, and the requirement that the attachment be made to the Bell system with a device produced by Bell. Although they argued that technically it was costly and difficult to make such attachments, Bell was able to provide the interconnection device quickly after the FCC authorized Carterfone attachments.

Carterfone greatly opened the market for foreign attachments. These devices included such items as recorder-answering systems, burglar alarms, local switching and intercom systems, and a host of additional, specialized products. The manufacturers and developers of these devices certainly benefited from the *Carterfone* decision. Bell was required to make a major adjustment in its attachment policy and in its technological development. Currently, the device necessary for attachment is being produced under Bell license by non-Bell companies and is installed in the actual foreign attachment rather than on the telephone line after the device has been purchased. Thus, the cost of such interconnection is included in the price of the attached device, the Bell's fee is a license fee paid by the equipment manufacturer.

Although the AT&T system could certainly capitalize on the vast and increasing market for such services, it chose not to provide such systems or services, except local exchanges. It has settled for an attachment fee for the use of the Bell-designed attachment device, which must be incorporated into all foreign attachment devices. The telephone company appears to have ignored a major service market that is currently developing, and which the company did not service for a number of years while it pursued its absolute ban on foreign

attachments. It seems that either Bell could not compete in price with other manufacturers in this field, and therefore did not respond; it chose not to try because the *Carterfone* decision caught Bell off-guard and unprepared to compete in that market; or it chose to make its capital investments in other areas. Most observers would define this market as a portion of the natural monopoly area of the common carrier, but it has not been absorbed by the monopolist in this case. As a result, a large number of small manufacturers are competing in this field, and the optimality of this arrangement is unclear. However, the development of new devices and technologies is proceeding quite rapdily.(22)

The model of the *Carterfone* allocation decision is shown in Figure 5-7. Here the demand of the new entrant (*Carterfone*) was supported by the FCC over the strong opposition of the established industry (AT&T). Bell voluntarily dropped its initial appeal to the courts, and it filed new tariffs with the FCC within six months of the *Carterfone* decision. The net result of this decision was the strong encouragement of technological development in an area previously having very limited market potential.

Specialized Carriers and Competition

A characteristic of the telephone company is that it is a common carrier, which means that it provides service to all comers, upon demand, at a regulated rate. In the past 20 years a group of carriers has developed using the same or different technologies to provide selected or specialized services to particular users. These services derive largely from the microwave link systems which developed after the microwave technology was devised during World War II.(5) The Bell system has a monopoly on long-distance transmission of voice

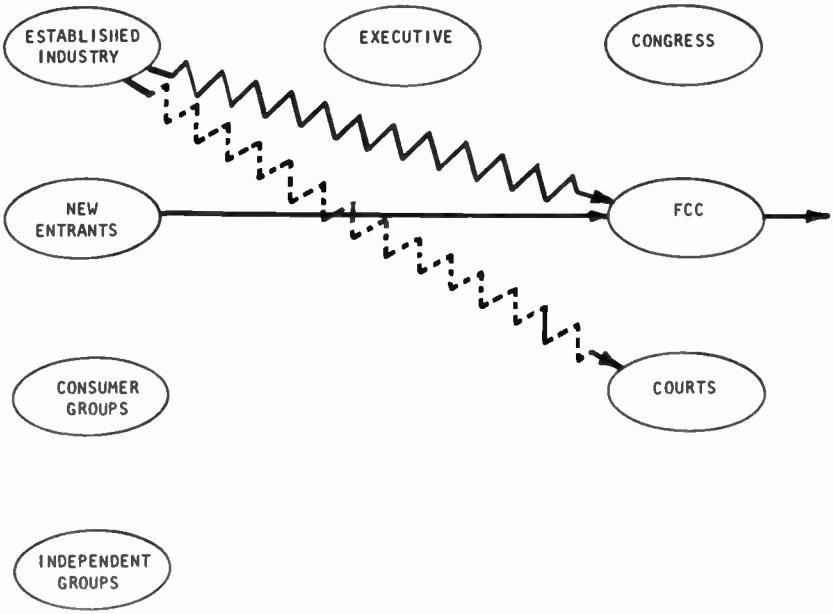

Figure 5-7 Foreign attachment model
Established industries includes the Bell Telephone system which sought to convince the FCC that foreign attachments were not necessary and were injurious to the telephone system. This same argument was presented to the courts for a short period of time.
New entrants included Carterfone, as later many other equipment manufacturers, who argued that such attachments were permissable and noninjurious to the operation of the telephone system.

communication over microwave links in this country. It has developed an extensive microwave system, and nearly all the long-distance telephone calls made in the country (37 million per day) are carried over this system.(26)

New entrants, willing and able to provide similar microwave based services, began appearing in the late 1950's. The new services and the lower rates which they proposed would require more of the electromagnetic spectrum than was then allo-

cated for microwave systems. The initial question was whether adequate spectrum was available to accommodate these competitive requests, or whether the economies-of-scale argument would support the monopolist's claims of the AT&T system that only it should be allowed to use the microwave frequencies for long-distance communications.(27)

The Above 890 Decision

In 1959, the FCC made a major break with established policy by its *Above 890* decision, in which it held that the spectrum above 890 MHz was large enough and technically open for use by other carriers using microwave links.(28) This was a first step through the door for other potential carriers, but little came of it at the outset since there were no applicants to use the spectrum above 890. Most of those advocating that the commission open up that portion of the spectrum for microwave use were not interested in becoming carriers but rather would use such proposed services or would benefit because they manufactured equipment necessary for non-Bell carriers to utilize that portion of the spectrum.(29) This is an interesting point, since the potential users were in the background during the early fighting to open up the spectrum and appeared only some years later with specific proposals for using the spectrum. The battle was initiated by equipment manufacturers and customers.

The Bell system responded to the *Above 890* decision by providing services which it had not provided earlier.(30) These services included Telpak rates for the rental of data transmission lines in smaller sizes than the Bell system had provided earlier, and at rates low compared with Western Union's Telex system. In fact, the FCC eventually disallowed some of the lower Telpak rates as predatory after formal complaints had been made by Western Union.(31) The Wide Area Telephone System (WATS) lines were devised in response to the threat

of competition during this period, again in an effort to provide a marketable package, at an attractive price to customers. This suggests that once the common carrier monopoly was faced with potential competition, it began changing the product it provided.

The MCI Decision

The first decision of the FCC which licensed a new specialized carrier in the above 890 MHz portion of the spectrum was the *MCI* decision in 1968.(32) (See Appendix). MCI proposed to provide only a microwave link between St. Louis and Chicago, nothing more. The user would have had to supply its own distribution link at either end of the line. The major attraction of the MCI proposal was that the cost of the service was much lower than that of AT&T. Furthermore, the MCI service was designed for small users who needed the communications link only occasionally or for short periods of time. Thus, the market MCI sought to reach was comprised of low volume users which the Bell system did not adequately serve. The FCC approved the MCI application for construction permits over the loud objections of AT&T which argued that MCI's proposal did not provide a new service, that it would be a nonoptimal use of the radio spectrum, and that MCI was not financially responsible enough to entrust with the building of the link. The commission based its decision on the prospective customers which MCI had exposed by market research, the economic position of the company, and the fact that the proposed service was indeed different from that provided at AT&T because it reached a market which the common carrier had not recognized earlier and which it certainly was not serving when MCI made its proposal.

Although the FCC was careful to state in the *MCI* decision that that decision would not be considered a binding precedent for future applica-

tions of specialized carriers, the *MCI* decision prompted a flood of proposals from other entrants in the area of specialized carrier services. In fact, during the year after the *MCI* decision, proponents made 37 applications, involving more than 1,700 microwave stations--over one-third as many stations as the entire Bell system had.(5) The Data Transmission Company (DATRAN) made the primary proposal for a nation-wide, switched network to be used solely for data transmission. The DATRAN proposal offered complete data transmission service, which would expend some $350 million.(33)

The DATRAN proposal was significant because it offered to provide a data transmission service which the Bell system did not then provide, and it offered to establish, at great expense, a nation-wide microwave system to do it. The data transmission business arose during the 1960's as more computers developed and the networking of computers became feasible and highly beneficial to users. The Bell system did not provide any major data transmission services, other than to permit the leasing of a voice-grade telephone channel over which the user could choose to transmit data. This was expensive and required the user to tie up much more channel capacity than necessary to transmit data.

Bell's response to the proposals for data transmission systems was a major effort to develop the technology to permit it to transmit data quickly and cheaply.(29) It came up with a system it called Data-Under-Voice. This required minor adjustments at low cost to the existing microwave system Bell used for long-lines communication. Bell's data competitors sought to prevent the use of Data-Under-Voice at the price Bell proposed because it was much cheaper than that which they had to charge to recover the costs of building an entire system.(34) But Bell did not develop the Data-Under-Voice system technology until challenged by new entrants,

who sought to provide this service. Bell either felt little need to service the data transmission market, until competitors tried to enter, or it simply did not choose to provide a means cheaper than voice channel in order to service the demand. The technology Bell developed in response to the threat of data transmission competition involved a major effort at Bell Laboratories--almost a crash program. It began the program in earnest after new entrants presented a competitive threat to Bell's monopoly position.

Bell also responded to the challenge of specialized carrier competition by lowering specific rates on service for which competition appeared. As noted previously, the Bell system uses rate averages so that some services return revenues much higher than the costs of that service while others do not "pay" for themselves. If Bell were able to identify the costs of a particular service and then charge a rate according to those direct costs, some of their services would cost a user much less than the averaged rate, and Bell sought to charge this actual-cost rate for some of these services. The new entrant-competitors challenged these pricing practices as predatory and as contrary to the rate-averaging, rate-of-return structure which Bell has followed as a regulated industry for some years. The Federal Communications Commission invalidated some of Bell's rates on the grounds that they were not average, and the direct costs of the service could not be identified clearly enough to warrant such pricing of the services. Bell argues that if they are to be faced with competitive new entrants for some services, which involve "cream-skimming," according to Bell, then the common carrier should be permitted to *compete* with the new entrants.(34)

Problems in Competition

The injection of some competitive elements into the services of the common carriers raises important

economic and political questions for the regulator. First, if it is beginning to consider competition as a tool for regulating an industry, should the entire regulatory scheme be examined with an eye to making all necessary adjustments so that competition achieves the desired results? The regulator will have to articulate what its objectives are and what policies it is seeking to implement by permitting new entry. Then it will have to spell out how these objectives will be achieved by the competitive efforts.

The second question about this competitive orientation is how can the regulator identify the extent of the natural monopoly which a common carrier should enjoy?(5) That requires outlining with what services and in what forms the new entrants can make a profit or contribute a service. The precise boundaries of the services for which the economies of scale operate are difficult, if not impossible, to identify. Yet, it is in these areas that the natural monopoly should exist. Recent efforts suggest that there is little likelihood of the new entrants achieving economies of scale on intercity telecommunications services.(35) Since its original efforts in the specialized common carrier market, DATRAN has failed financially. This is one of the major, long-term problems with selective competition and economics of scale. A further part of this question is, should competitors be permitted to try to compete where the investment pattern is highly capital intensive?

A third important question has recently arisen. The new entrants are seeking protection from the common carriers for their various rate structures and services.(36) DATRAN asked the FCC to bar Bell from instituting part of Bell's 24-city data transmission service which would directly compete with DATRAN's. If the common carrier can provide identical or better service for less or equivalent rates, should users be prevented from choosing the

cheaper service--in a competitive market which the FCC apparently seeks to create--because the new entrants will not be able to survive economically if competition really breaks out with the common carriers? This policy question has various answers depending on what one's goals and values are. However, if competition is to be used for regulatory purposes, the regulator must spell out and follow a clear set of objectives unless the morass of regulation is to increase and impede future developments.

The MCI Decision Model

Figure 5-8 presents a model of the *MCI* decision. The participants include the established industry (AT&T), the new entrants (MCI), and the users or potential market. The efforts of these people include active opposition by AT&T. The potential MCI customers provided support for the MCI application which the commission partially relied on for its decision. Of course the proponents (MCI) actively made and defended the request, which was successful. The established industry sought court reversal of this decision, but to date this effort has been unsuccessful.

The Video Telephone

The development of the video telephone illustrates several important considerations which have not been discussed thus far. Primarily, the development of this device has not been directly regulated by any government agency. In fact, this system has largely resulted from private development and technical decisions, particularly by the Bell Telephone system. This fact alone may explain some of the unique technical developments and failures which have occurred in the long history of this device.

The Bell system began developing a video telephone (the Picturephone®) in the 1940's and early

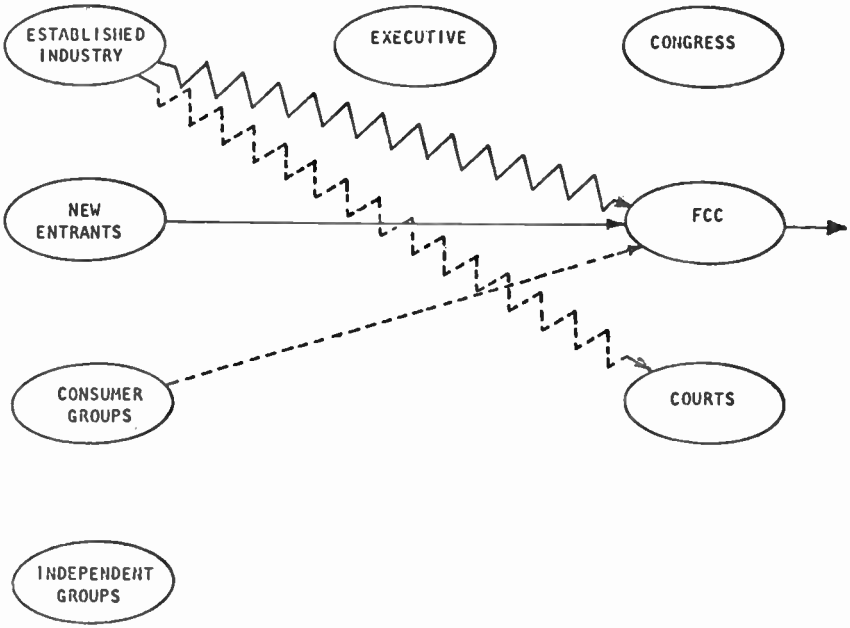

Figure 5-8 MCI decision model

Established industries included the common carriers, particularly AT&T, who argued that the proposed service of MCI would not meet a need that was not already being met by AT&T. The company later challenged the FCC decision in the courts, but lost.

New entrant was the MCI Company which sought to provide the competitive microwave link between Chicago and St. Louis to meet demands not then met by AT&T.

Consumers groups involved the potential MCI service customers which came forward to support MCI's application before the FCC.

1950's,(37) billing it as the logical extension of the audio telephone. Bell's technical decisions suggest that it intended to market the Picturephone® primarily as a face-to-face communication device and did not intend to emphasize the other potential uses of the video telephone. As a result of this marketing approach, the Bell develop-

ment emphasized picture quality adequate to transmit faces, not written documents.(38) This approach virtually eliminated alternative potential uses to which a video telephone might have been put.

Technically, the Bell video telephone, which was first to be announced and marketed, used a 251-line, 30 frames per second picture transmission system. This compares with the broadcast television system of 525 lines and 30 frames per second. Because picture quality on the Picturephone® was appreciably lower than that of a commercial television receiver, it was far from adequate for transmitting pictures of written data. In fact, pictures transmitted by commercial television do not provide clear reproductions of normal written material, even though such transmission uses twice as many lines (525). The amount of bandwidth used by the Picturephone® is 1 MHz, which is about one fourth that used by the video portion of a commercial television system (4.6 MHz). A bandwidth corresponding to nearly 100 voice channels is required to transmit one Picturephone® conversation.(37) This technical requirement would have an enormous impact on the amount of telephone switching and transmission equipment which the Bell Telephone System would have to install in order to replace the existing audio system with a video telephone system. Since one video conversation would be equivalent to 96 audio conversations, the growth in plant would be astronomical in order to completely replace audio telephones.

Bell's development of the Picturephone® continued until the late 1960's when it began first marketing efforts in Chicago, Pittsburgh, and, later, Washington, D.C. The service provided for the video telephone was local only, so the subscriber could not use the device to make long distance calls. Furthermore, in the initial stages of marketing, few other people with Picturephones® could be called. Most of the early users were com-

mercial establishments which used the Picturephone® for interoffice or interplant communications, or for customer shopping. The cost of the service was much higher than for regular telephone service, because of equipment and installation costs, but apparently the cost to users was lowered in order to make the device saleable. Even so, there seemed to be little demand for the service, and the Bell System has suspended marketing the Picturephone®. (39,40) One former Bell Laboratory official has indicated that the world was not ready for the Picturephone®.(41) Other less favorable comments suggest that the Picturephone® has been a "flop."(42)

It has been roughly estimated that Bell spent hundreds of million of dollars in the research, development, and pilot production of the Picturephone®. Whether or not this is an accurate figure, the amount spent has not returned any revenue. While there may be explanations for such results, there are no clear answers, and the ones provided are tentative at best.

The first explanation is that Bell totally misjudged the market for such a device. One observer has suggested that the estimated penetration of the market could have been around five percent, certainly not a major portion of the telephone market.(37)

Second, it could well be that Bell failed to estimate the psychological factors which might inhibit people from using the device. However, since the public never widely used the Picturephone® , psychological inhibitions, which do seem to exist, could not have been the significant factor.(43)

A third, and more probable explanation, is that the system was designed to do little more than provide face-to-face communication. Perhaps, the crucial need is more for a system which transmits pictures of documents and other written materials.

The Ericsson Telephone Company of Sweden, an international telephone equipment manufacturer, has

done much recently to develop a different video telephone system. This company emphasized an entirely different orientation toward the functions of the system and its viability. The Ericsson Company has focused, not on face-to-face communication, but on transmission of written documents.(44, 45) It utilizes a system with a much sharper picture than the Picturephone®. The Ericsson system involves 625 lines and 25 frames per second. This is the European standard television system, which provides a sharper picture than American television. The price of obtaining this sharpness is a substantial increase in the bandwidth required. The system requires 5 MHz for the transmission of its picture and voice, nearly as great as the bandwidth of a commercial U.S. television channel. However, to reduce the cost of this transmission system, Ericsson has so far used it only where the entire system could be wired into a single plant. In preliminary tests Ericsson installed the system in its home office in Stockholm and used it among various offices of the production, design, and order units. Ericsson wanted to reduce the need for face-to-face conversations where technical details had to be discussed and modified, and it found that the saving in time and reduction in delays could pay for the complete system in three years.(46)

This use of the video telephone differs substantially from the proposed uses of the Picturephone®. It replaces internal conferences and upgrades interoffice intercom systems by transmitting drawings and other written documents. While face-to-face conversations are possible, the usage was heavily oriented toward transmitting documents. The picture resolution was quite high, compared with the Picturephone®. The resolution of the picture, an approach rejected by Bell developers, makes the system valuable. Ericsson is beginning to market the system to other users on a limited basis, but, it is emphasizing use of the system primarily within an office or organization.

The bandwidth requirements of the Ericsson system would place tremendous channel-capacity demands on a telephone system for long distance service. To make possible long-distance transmission Ericsson has developed a slow-scan system.(45) It samples the picture and transmits only those portions of the picture which have changed (moved) since the last sample. There is a time delay of some 30 to 60 seconds for transmission of a single picture. However, this delay does not seem crucial in long-distance transmission when the primary picture usage is for documents. The slow-scan system allows the bandwidth to be compressed down to 1 MHz which is the same as is used in the Bell Picturephone® or even down to 4 kHz which is the bandwidth for a regular audio telephone voice channel. The long-distance use of this system has been limited to experimentation.

The video telephone development experiences of the Bell and Ericsson companies represent basic marketing and technical differences, which may lead to differences in the success of the two systems. Bell's philosophy appears to have been incorrect, in that it did not achieve the desired results. Ericsson seems to be quite encouraged about the early success of its system, although it is too early to confirm its "unqualified" success. The Ericsson system is based on a more restricted and limited use of the video telephone, and that approach may be the difference between success and failure. The video telephone appears to be quite useful and successful for certain, limited functions, but not as a replacement for the basic telephone.

This technological endeavor and its results suggest that careful examination needs to be made before a technology is developed and chosen for a new system. Many wonderful technological devices, possible within today's state-of-the-art, may never be realized if careful market analysis and evalua-

tion of psychological parameters of the device are not explored and properly taken into account. These considerations are difficult, if not impossible, to carry out precisely. Yet, without analysis and evaluation new technological innovations may be doomed. As the video telephone illustrates, such decisions can be made in various ways, and the developer will have to live with the consequences.

Summary

The development of integrated circuit technology has made it economically possible to produce complex electronic components and systems. The modern electronic computer, communication satellites, and the electronic switching systems of the telephone companies are typical examples of systems made practical by integrated circuit technology.

The computer has also created a demand for a new kind of telecommunications service--data transmission. The need for greatly expanded data transmission services has led new entrants to attempt to enter the marketplace and to supply such services between cities. This has raised difficult regulatory problems for the FCC since it must give the basic authorization to provide such services.

The difficulty arises because of rate determination policies that have developed over the years. Rates for each telephone company service are obtained by averaging over a wide variety of services and locations so that they do not represent the actual costs of that particular service. This has made it possible to cross-subsidize certain high cost services such as rural telephones and local calls from revenues obtained elsewhere, e.g., long distance calls.(47) If new entrants are going to provide limited services at rates which reflect only the costs of those services, their rates may be very different from those that would have been

charged for the same service the telephone company provided. In the case of data transmission, the telephone company already has microwave links installed and could likely provide services at much lower cost than a competitor, if only the marginal costs of supplying the service were charged.

On the other hand, without a competitor the phone company would probably structure its rates differently and use part of the revenue from this service to reduce the costs of other services. It is this confusing area into which the FCC has stepped, licensing of new entrants such as MCI and DATRAN in the data transmission field, and authorizing competitive domestic satellite systems.

The pattern of regulation by the FCC has generally been that of supporting the established industry wherever its continuing business is concerned. This applies to broadcasting as well as to two-way telecommunications. However, where new services such as those stemming from use of foreign attachments, intercity data transmission, and domestic communication satellites are concerned, the FCC seems willing to allow a limited amount of *apparent* competition. The degree to which a competitive situation actually develops will be determined by the methods of rate structuring the FCC allows. Judging by previous performances all of the companies will be required to charge the same rate for the same service and there will be little real competition. Therefore, the degree to which society will benefit from the pseudo-competition authorized by the FCC is uncertain.

The switched telecommunications system in the United States is dominated by the Bell System and there is little reason to doubt that this situation will continue to prevail for many years to come. Bell has vast resources and is determined to improve and expand its services and to compete strongly with any new entrants in its marketplace. Because of the intricate nature of the rate-averaging

process Bell uses in determining costs of services, extensive ramifications in costs of apparently unrelated services probably will occur when something is done that forces a change in the cost of a particular service. There is considerable doubt whether meaningful competition should or even could be introduced into today's system. This is particularly important because causing a significant degradation in certain services by such a process might actually be easier than causing a significant improvement. It must be remembered that the telephone service is generally excellent and nothing should be done that might degrade it. A radical alteration in services is not needed so much as altering the directions of technological development to provide services and equipment more responsive to users' needs and wishes. This matter is discussed further in the next chapter.

Chapter 6

Telecommunications' Impacts on Society

From earlier discussion in this book, the course of development of telecommunications technology and services varies with many factors. However, it is also important to consider what impact telecommunications development has on the society which uses the various devices and services this technology supplies. Precise discussion is not possible because the impacts are so numerous, so difficult to measure, and often evolve so slowly that they cannot be clearly discerned. One can hypothesize or guess about what effects technology has had or will have. Some individual technologies have provided clear and precise examples. However, to present a comprehensive picture of what effects telecommunications technology has had on American Society would be impossible. This chapter will examine several areas which have been documented and in which there have been or will be impacts. This will isolate selected topics and ignore other areas. Though the best treatment would be to explore the area systematically and completely, such an effort would require a large and extensive study, far beyond the scope of this book.

Some Areas of Impact

It would be useful to examine the impact of telecommunications technology by using some sort of

framework or approach so that the effects can be placed in perspective. The framework which will be used here is a general one. It consists of grouping under appropriate headings major segments of society which have been directly or indirectly affected by telecommunications developments in recent years.

Politics and Public Institutions

The changes which telecommunications devices can effect in this area are both promising and potentially dangerous.(1) First, it will soon be possible to take public opinion polls, almost instantaneously. These will give the elected public officials some remarkably accurate readings of what the public prefers on a policy or general subject at any particular instant. This could be done by attaching a two-way device to all sets on a cable TV system. Readings could be tabulated in computers linked across the nation so that the officials could tell, by state, region, or individual, what policy preferences were held on any issue. This would profoundly affect the conduct of official business, since a basic element of a democracy is that the wishes of the people be implemented. Even competing interests make such a task difficult, and simply knowing precisely the wishes of the people would greatly facilitate political decision making in which these interests are considered. This would make it difficult for a Congressman or Senator to vote on a bill without at least knowing what his constituents felt about the issue, even if he or she chose not to support these feelings.

This phenomenon, which we might call instantaneous democracy, would provide the decision makers much information which they have to guess at or have to pay large sums of money to discover now. Such a system is not without its difficulties since

instantaneous voting or polling on issues might inject a lot of instability into the system. Thus, if major policy issues were decided by voting or polling in this way, much of the slack and delay in the political system would disappear, and this might cause the government to become less stable--to the point that extremists or small groups could, under emotional circumstances, control the government and drastically change what the political system did and how it did it.

To date, no one has advocated that such an instant polling system be introduced, either because of apprehension over what effects this might have on the operation of the political system or because it is too costly. Instant referenda are not now considered viable. However, the technology to achieve them exists. Some public officials have taken advantage of lesser technological advances to tap, more closely than before, their constituent's views. The installation of a WATS telephone line between various offices in the district and the legislator's office gives his supporters a "free" chance to let the official know what they feel on any subject they choose to discuss. This means is not as representative or as instantaneous as the poll, but it does give the representative better information than was available in the past, and at a fraction of the former cost.

In addition to such polls, the general telecommunications expansion permits political decision makers, like others who must decide, to recall and use vast amounts of data and data analysis which used to be impossible. Thus, a legislator, or a chief executive can use computers and large pools of data before deciding many of today's policy issues. This would not be possible without current telecommunications services and continually decreasing costs. These facilities expand his perspective and his understanding of a policy problem before he acts.

A major development in politics and telecommunications has been the development of news reporting, particularly of elections by the television networks and other media.(2) A major television network can usually predict the outcome in statewide elections on the basis of small numbers of votes which are reported early in an election day. This ability is due, first, to the development of sophisticated statistical techniques, and, second, to telephone communications and computers. Whether this projection of outcomes affects other voters, who view them before voting, appears doubtful.(3) However, processing this information and disseminating it has become nearly instantaneous. Possibly the television communication system is the primary way people obtain their information about political candidates, and the way they base voting decisions, although this is not borne out by empirical studies. Again, empirical evidence suggests that the electronic media do not have much impact with many people, though the potential is there. This is due largely to the ability to communicate rapidly with many people.

A set of questions relating to telecommunications technology involves the government's use of personal data and investigations of people.(4) The data bank problem has been discussed widely in recent years, because of proposals to create a national data bank which would pool various existing sources of information on people. For example, the FBI has vast files of known and suspected criminals; the Social Security Administration has a file on everyone with a social security number. The collection of such information as living habits and styles, health records, credit records, and other kinds of data could, when pooled, produce various kinds of "profiles" on people which might be inaccurate, might be used for various unintended purposes, and might seriously injure persons and their reputations if not controlled and monitored carefully.(5)

Whether the government will use such files, and what sorts of controls the government will likely place on the collection and use of such personal data by agencies are important questions and problems which bear watching in the years to come. As communications technology develops it will contribute greatly to the ability to create such files, use such information, and control its usage.

Other considerations are important. One of the most important involves the area of censorship and the fact that the free press privileges in this country are well established and have a long history. Where official, governmental agencies establish or control information, the possibility of a vast system exists to control more information. However, many independent broadcasters and news sources reduce the likelihood of such censorship. If the government can control the channels of communications and can determine what is presented, then the people hear only what the government wants them to hear. The situation portrayed by George Orwell in *1984* may come true, since modern telecommunications technology would permit centralized and complete control of the channels of communication.(6) There may be great protection from this danger in radiated signals, since a government cannot as easily control what is broadcast as it can what goes through a coaxial cable. If every home has an optical fiber which brings all communication services into the home, control of that system by government would be easy. However, if parties are permitted to broadcast over-the-air, establishing such control is not as easy. Some governments in the world control radiated signals closely and seek to provide the user with only one view of the world--that government's view. However, this is more difficult when there is no single point in the communications system through which all communication must flow. Such a situation will not likely develop in this country, but

the technology permitting such control of information exists. A safeguard against such developments is the use of multiple information sources and multiple technologies.

Consider that technology would permit new and different forms of propaganda broadcasts. Thus, closed-information countries now use various technical means to jam broadcasts from foreign governments or other propagandistic sources. However, communications directly from satellites to home receivers could happen.(7) If it did, the target government would have to develop new ways of intercepting and blocking such transmissions. The likelihood of this occurring and the need for countermeasures depend on the political situations in various countries. Obviously the occurrence of this in some countries today would be strongly opposed and in other countries might prove beneficial. The technology is certainly available, but whether this develops, how it would be used, and what the precise results would be depend on the political situation in various countries.

Commercial Transactions and Institutions

The way in which business is conducted depends largely on telecommunication services and, as time goes on, that dependency will increase. Today's commonplace ability to dial any telephone in the country, directly, makes the conduct of some businesses much easier than in previous times. The ability to have a continuous communications channel with a production plant thousands of miles from the main office, permits a company to monitor closely the conduct of its business, reducing the costs of unforeseen delays and increasing profits by having sufficient inventories available at appropriate times. Besides being linked by a telephone system, a company can use devices in its internal communications system such as the video telephone, services totally impracticable 10 or

even five years ago. In addition, more traditional intercom systems and local switching systems greatly facilitate communications with customers, supervisors, and anyone else who is concerned with the business.

The development of new devices to do old tasks, such as computers to do accounting, can provide incentives for companies to use such devices to accomplish even more. Thus, the company may begin performing new services or functions, even though these were not anticipated or intended at the outset. The capability of a central office to have instantaneous control of production plants and warehouses all over the country means that businesses can be run more efficiently and with greater ease than was possible a decade ago. Banks can now conduct many of their customer-related transactions without need for a teller, since, electronically, all the necessary information can be provided by the user at remote terminals. The concept of a cashless society, founded on the plastic credit card, is more a reality than a speculation. The monitoring of credit cards--checking validity--is quite simple, and the transaction in many stores occurs instantaneously, so long as the customer has his card with him. What these procedures permit is immediate transactions covering the full range of normal customer services.

Furthermore, new shopping services can arise with current technology. The home terminal would permit local merchants to advertise or merely list their merchandise on a cable TV channel. People interested in the product could see the price and indicate their preference to purchase some of the items by using their two-way communicating device in their home.

Telecommunications devices could make it possible for business executives to work in their homes, rather than travel to an office every day.(8)

The home terminal device could provide the businessman with broadband capabilities so that he could obtain any information he needed by dialing it on the terminal. It could permit him to confer with his colleagues by switched video telephone, allow him to dictate to a secretarial pool, and enable him to receive the finished, hard copy all at home. Such operations are in use now, but their cost is high. The saving in travel and building rents may eventually reduce the costs to nearly a trade-off with current costs of doing business. Such a work setting would change lifestyles and habits of many people. It would require the adjustment of roles by family members and by workers. Such a system would require a major adjustment in business organization and operation. It could be achieved, technologically, and would provide the modern businessman and company with opportunities and functions far beyond current practice.

Certainly, the information revolution, largely the result of current telecommunications systems, can provide the executive with a much larger amount of information and data upon which to base decisions. The immediate analysis of vast amounts of data is possible. The executive can request production data and plant inventories and obtain this immediately. Then the executive can project the possibility of meeting a particular deadline or filling a large order. Such decisions used to be based on hunches, conversations with plant supervisors, and expectations about the near future. Now the decision can be based on hard data and more precise and accurate calculations. Though not all companies use such systems, some do, and they find it economically beneficial. Companies which do not use such information processing systems are or will be placed at substantial competitive disadvantages. Many will either adopt such procedures or lose out to competitors who have them.

Delivery of Services

Some of what has just been discussed indicates that new communications systems will facilitate the ways of providing services. Thus, new telecommunications devices may change established services. For example, the way that companies bill their customers and the methods by which they keep their books will be changed by the inexpensive computer linkages that are available. Many people have had to confront a computer to deal with an error in a bill, and they have achieved various forms of success by "folding, spindling, or mutilating" their punch card. Even with these difficulties, though, all sorts of businesses find it easier, quicker, and cheaper to bill customers by computer services--often rented or shared computers connected to users throughout the nation by long-distance telephone or data transmission lines.

Education may be a major beneficiary of modern communications systems. The use of computers to aid instruction has developed in the past decades because of computer interconnection permitting students, throughout an area or even the entire country, to tie into a single computer installation for a particular, programmed course of instruction. Despite costs, still high, computer-aided instruction is developing and expanding into new areas and subjects. This has not been at a revolutionary pace, but gradual changes and developments have permitted the perfection of the system and its expanded use.

Computers are being used, nationwide, to provide bibliographic searches. This use permits speedy acquisition of materials on a subject without an intense effort of physically examining the references in a library. There are specialized services for this purpose, and there are some general services which permit someone interested in any one of a multitude of subjects to obtain

and use the service rapidly. Costs of a search are currently a factor for the individual user since they are relatively high. However, with increased usage, especially by institutions, the cost will decline to a point making any individual use of the service feasible.

The delivery of health care service has been changed and will be changed further by telecommunications devices. The continual need for doctors to learn about recent advances in diagnosis and treatment can and is being met by medical education systems which use cable TV channels or closed-circuit television.

Provision of emergency medical assistance has been facilitated by telecommunications devices which permit the ambulance to transmit various, vital life-sign information from the patient to the hospital or emergency treatment center. This can be crucial since additional minutes of monitoring and treatment can mean the difference between life and death.

Even nonemergency transmission of medical information from one hospital to another or from the small community to the medical center where specialists can examine and advise on the treatment of a patient is frequent and possible because of telecommunications systems developed in recent years. The ATS-6 experimental satellite discussed in Chapter 5, providing broadcast service over India, was used for medical education and diagnosis transmissions in Alaska, where great distances separate communities. The success of this service is encouraging because it provides hope for better medical service to people in remote areas.

Telecommunications systems have altered law enforcement procedures dramatically. The networking of communications permits a local law officer to learn in minutes if a person detained for a traffic violation is wanted for other criminal activity by police in other jurisdictions. Communications with

a central information center can provide the officer with nearly instantaneous information on whether a suspect is driving a stolen car. Fingerprinting, a major means of identification, can be computerized, and that process is proceeding, so that identification by such a print can occur within minutes of a request, no matter where the request comes from. Telecommunications systems have tied a number of communications centers together so that it becomes easier and quicker to deal with emergencies and information needs of a community regardless of distance or size. Centralized emergency numbers, such as "911" systems, provide a simple and direct means for any emergency to be brought to the attention of a central dispatcher who can refer the call to the appropriate agency.

New Industries

The development of technology in telecommunications has produced many far-reaching industry and economic effects. The telecommunications industry comprises a substantial portion of the industrial structure of this country as well as others. The telephone system alone requires an annual capital investment of $10 billion which is a substantial part of the nation's total private investment capital. In addition, the electronics industry, a direct result of the development of new devices and their adoption, has grown in the past decades into a billion-dollar industry which provides large amounts of materials for various operations throughout the world. The ability to miniaturize electronic circuitry has meant that various industries can be established and can operate successfully anywhere in the world. For example, the Japanese industrial development since World War II has been greatly accelerated as a result of the development of their electronics industry. Many of their materials and components are produced in this country and then shipped to Japan for assembly.

No radios or black and white television sets are produced in the United States because it is more economical to mass-produce these items in Japan and ship them to the U.S. for sale.

The production of telephone equipment in this country is divided between a major producer--Western Electric--which produces only for the Bell system, and small companies which make various components for the other, independent companies. Small producers have little of the market to deal with, except that Bell apparently does contract some component production out to those companies. Western Electric has nearly all of the "market" even though it does not compete with anyone for the Bell System business. A former Bell Laboratory official feels that the production of telephone equipment could be lost to Japanese companies if the current Department of Justice antitrust suit against AT&T succeeds.(9) If this happened, it would be because the production costs for Western Electric, reflecting actual or real costs, are higher than for Japanese producers. Whether this would be good for the American economy is an open question, however. Much of the exporting of industrial work results from market factors and the technological setting in various countries. The ability to continue to produce this equipment in this country will depend on continued technological advances here which reduce costs, or which give the United States industries a technological superiority over foreign competitors.

As telecommunications grows and changes as a service, new companies with new functions will arise. Whether they succeed will depend on economics and on the technological devices and service involved in the industry. Generally, the electronics industry has been quite successful in this country although it must contend with ever-increasing foreign competition. As new breakthroughs occur and new devices and services are adopted,

there will be incentives for continued development of those new industries.

Life Style Changes

Much concern has been expressed about the effects of telecommunications on individuals and on society. This is an important but also a complex subject, difficult to explore and to arrive at hard conclusions about. Presented here are some possibilities which appear as a result of empirical studies conducted on the subjects. There are two dimensions to this impact--the interpersonal relations which the new devices cause to be changed, and the individual, psychological impact of these devices on particular persons.

Interpersonal Relations. Probably the most visible impact in this area has been the effects of mass media on people and their lives.(10) Contact with people is often structured around television, adjusting the way people think about others and the way people react to each other. As the central socializing agent in this country, the family has seen its role change greatly since youngsters spend more time before a television set than they do in school. During his or her first 18 years a youngster has spent an estimated 12,000 hours in the classroom and 20,000 hours in front of a TV set.(11) The way families are structured and the roles which parents play have changed because of television. The parent no longer is the only source of ideas, values, and morals for youngsters. As the technology permits, children may obtain more information and education from a two-way communications system in the home than from school and parents combined. There will be a variety of societal controls over such teaching and instruction, but the child will also have to adapt to a changed situation in the home, where the parent, as teacher, becomes more separated or distant from many of the child's experiences.

Family ties vary among families, and some ties are as strong today as they were several generations ago. However, as the youngsters are exposed to additional, external stimuli from mass communications systems, they will turn less to parents for guidance and more to the other sources. In addition, as the function of the family changes, as it is no longer the central economic unit (as in the case of agrarian societies), the importance of the family bond for youngsters is likely to decline. Parents, too, will feel the pressure of change as a result of telecommunications devices which require an additional telephone in the home for the child or a new room where the child can go to learn. While this may not occur immediately, these influences are appearing and become possible with continuing introduction of new communications systems and devices.

In addition to changing intrafamily relationships, changes in communications are likely to change the setting of individuals and their relationships with fellow workers. For example, if persons do not have to go to the "office" because they have a terminal in their homes which gives them access to everyone and everything they need to perform their jobs, these persons will have to react and adjust to this. Not having to leave the home to work may affect not only the workers' families, but also nonfamily members they deal with though not having met them personally. Individuals working in their homes may find the adjustment difficult. However, for persons who have worked at home from the time they began elementary school, as some future generations will, the problems will not be the same. Generally, interpersonal relationships which result from the ease of communication will probably affect how people react to one another. Will people find it easier or more difficult to approach strangers and strike up conversations? The audio telephone imparts a degree of anonymity to the caller which might make it easier

for some people to use the telephone for business and other purposes, than if they had to use a video telephone over which they could be seen by the other conversant.

Psychological Relations. How individuals react to these telecommunications services will depend largely on their psychological make-up. This, generalizing about these facets is difficult. Certainly, people have generally changed their tastes and values, because of television and other forms of mass communication.

More individuals are being exposed to increasing amounts of information--commercial-product information as well as decision-making information. No matter where people live, they are exposed to the latest fashions, the latest products, and the latest conveniences. Whether they can obtain them from a local store is another question, but they at least know about them. Noncommercial information also has been presented rapidly to many people. Thus, people face increased amounts of information about which they may know little or upon which they may grow dependent to make decisions. "Information overload" is a common term to describe the phenomenon of people who face more information than they can assimilate or cope with. This phenomenon will continue for years as communications systems facilitate the processing and manipulation of large amounts of information.

More people are also being exposed to universalized concepts and stimuli. Thus, television viewers see the same program and the same news presentation on national networks. This may create a commonality of information and value base which some would argue harms the heterogeneity of the population. Whether such common communication channels are destroying diversity in the American population is an interesting and an important point. However, it is impossible to arrive at any concrete conclusions about this possibility. The

mass communication system does provide all people with similar or identical information about an event. Thus, the entire country was exposed to the difficulties and problems associated with the Vietnam War. Each evening on the network news one could learn what had happened in the war the same or preceding day, regardless of where the viewer lived. The same occurs with entertainment the networks present. Throughout the country, people view the same drama based on the same human emergency or emotional crisis.

Another set of impacts on individuals stem from the socialization process which they confront as they grow, mature, and learn from the society around them. How a person adapts to his or her social setting, learns the roles which he or she will play during a lifetime, and acquires attitudes toward other people and institutions is crucial to any society's continuing existence.

Most of us are socialized by our parents, our peers (fellow students, workers, and associates), and by general sources of attitudes such as mass media. Traditionally the socialization process has largely resulted from parental guidance and schooling which occurs during a youngster's early years. However, research suggests that socialization continues throughout life, and the school, peers, and media appear to have a greater influence on socialization than do parents. Depending on the parents and their willingness and abilities, a youngster can gain nearly all attitudes and orientations from peers and teachers without registering much parental impact at all. As a result, telecommunications, particularly mass media, can play a major role in the socialization process of youngsters. It is this that has caused much concern about the generation gap which some observers see developing.

While the socialization process is important and should be considered in terms of telecommunications

technology, it is also important to consider the fact that much of this impact on people may well be unintended. Some observers argue that the mass media are consciously trying to develop certain kinds of attitudes and biases among the population.(2,12) There is certainly much concern about this and probably some truth to it. However, *even if* one assumes that the media are well-intentioned, there are many indications that programming and presentations give people particular perspectives, which they in turn act upon or at least use as a basis for their orientations towards others. In some situations, a person has learned to respond to situations from having watched a television program in which the identical situation arose. In other situations, the individual has adopted an entire identity and self-image which shapes his personality from media sources. Whether this clearly results from media programming, intended or unintended, or from other influences, the impact seems clear and should be considered by those interested in learning how the technology will affect the individual.

A major area of controversy about the impact of mass communications on society has been the effect of violence and violence-oriented television programs on children who watch them. Basic conclusions of researchers in this area do not *prove* that violent programs make children violent, but suggests that this can, and does, occur. Generally, a youngster with aggressive tendencies, or so inclined by other stimuli, is more likely to act out aggressions if they are reinforced by programming viewed on television. Competing theories include the possibility that television violence acts as a catharsis and replaces acting out of aggressive tendencies among watchers. However, there is good support for the proposition that some viewers, with aggressive tendencies, gain reinforcement for these from violent television programs, and may

act on these feelings as a result of viewing programs.(10,13,14,15)

Obviously, this area is important for society and various suggestions to reduce the amount of violent TV programming have been made. However, control of programs apparently will not come from voluntary network efforts, because violent programs seem to attract the most viewers and thus generate the greatest advertising revenue. Any governmental policy limiting the amount of violent programming would constitute prior censorship and would have to face a substantial court test regarding its constitutionality. The solution to this dilemma is unclear, and the final outcome may well be slight adjustments in the status quo which do not satisfy either side completely, but which may compromise their differences to the point of acceptance. However, the basic point is that programming can, and probably does, affect viewers, and, given the large amount of exposure to television which many children have, this effect is a serious social problem.

Another set of communication system problems relates to the individual psychological make-up of persons. This involves the anonymity which rapid and profuse communication systems provide. The individual becomes a series of numbers ranging from a social security number to charge account numbers issued by various commercial establishments. Some people will find this impersonalization destructive and disturbing. Coupled with the increased lack of privacy which can arise in a highly developed communications infrastructure, this phenomenon presents great problems for individuals and for society as a whole.

Many devices are operational and permit various sorts of data collection, ranging from tracking or locating devices to wiretapping and eavesdropping mechanisms. In addition, possible future devices that permit paging and telephoning systems to

reach anyone, anywhere, could create problems for individuals. The current growing concern about invasions of privacy presents important problems for society, and, as the devices for such invasions become more sophisticated, the problems will magnify. The thought of not being able to be "alone" causes deep concern for many people who view this as a transgression on a basic human, if not constitutional, right. For some this possibility would destroy a person's individuality and the ability to maintain his or her identity.

The Impacts

These suggestions of technological impact have only touched selected future problems. Some of the problems may never occur unless certain technologies and devices develop and are used widely. Thus, the broadband home terminal system will not require major adjustments in work styles or family and educational pattern if the systems are not well-developed and widely-distributed to the general population or if they emerge only slowly, allowing time for adjustment and adaptation. One development may have one kind of impact on American society, because of its highly developed social system, but may have a much different impact on another culture or society at a different stage of development. Thus, some impacts may be long range and depend on the speed of development as well as the target government or society.

Other impacts, clearly with us, present major problems for society. The telephone has been with us for many years, yet new telephone services are being offered almost daily, and these services require adjustments in life styles and commercial transactions as well as changes in political processes. Television is a widespread phenomenon in America, and, even if the precise effect of television is unclear, many examples and evidence suggest some of the major impacts which seem to result

from this telecommunication system. The development and growth of industries, even national industrial bases, are realities which are largely due to telecommunications technology.

Generally, the increase in communications and the ability to communicate rapidly with increasingly larger numbers of people is probably the major story of the technological impact. How our society or any other copes with this many-faceted set of pressures and problems is a major question. It is clear that systematically, or haphazardly, societies must cope with this ever-increasing and widespread net of problems.

Chapter 7

Future Telecommunications Developments

This book has explored how telecommunications technology has developed in the United States. To determine why this development occurred as it did, this book has examined the interactions of the forces among various political and commercial institutions. This chapter will suggest structural or policy changes, changes that might be made, which might alter constructively future developments of telecommunications technology. None of these suggestions is provided as the answer to a specific problem, and most of them carry with them or create some problems of their own. Hopefully, however, this discussion will provide the reader with thought-provoking material about what has happened and what ought to happen.

Alternatives to Present Regulatory Approaches

Telecommunication services have been expanding and improving continuously since their inception more than 100 years ago. Case studies in Chapters 4 and 5 show many forces at work in determining when and how various telecommunication services are provided. In some cases, potential services may never develop because political constraints are only marginally related to the public interest. In other cases, political and regulatory agencies may attempt to stimulate development of new serv-

ices by requiring that certain technological capabilities be provided or by permitting competitive situations to develop in an otherwise monopolistic industry. The two methods which appear to have been relatively the most effective in controlling new services are: the withholding of authorization for new entrants or the promulgation of restrictive and stifling regulations for such entrants; and opening up an area to free-market competition. Other procedures have been much less effective. In general most of the regulatory agency decisions are made so they do not adversely affect existing services of established industries. This means that the pivotal decisions are most likely to involve new services. Therefore, in this area consideration will be given to alternative approaches aimed at introducing a different balance of forces in the decision process.

With a change in the balance of forces it appears possible to alter substantially the evolution of telecommunications development. The key factor in any such procedure is a feedback mechanism that will prevent continuation of the development and evolution process when such continuation is not in the public interest. This factor is provided by competitive forces in a free market and is lacking in a monopolistic industry. Introduction of an equivalent effect can be accomplished by other means, and some such possibilities will be considered next.

Pay Television

An example of restrictive regulations is the current status of pay television technology and service. National networks and the TV broadcasting industry oppose pay television, seeing it as a major threat to the size of their audiences, which, in turn, would be a threat to advertising revenues. The broadcasters' strongest argument that relates to public interest is that the advent of pay TV

would eliminate "free television" and would represent a major hardship on the poor. This argument is difficult to overcome without changing some rules of operation for pay TV from those being considered. There seems little doubt that the main function of TV from the advertiser's and broadcaster's point of view is not entertaining the poor but, rather, influencing the purchasing habits of the nonpoor. The free entertainment of the poor is a fringe benefit to society paid for by the more affluent who purchase products advertised on TV.

For the sake of argument, assume that the existence of free television programming and pay television and its potentially greater range of offerings are both desirable. How might these two objectives be made mutually achievable? One approach might be to make pay TV available only at nonprime time--say from 10 p.m. to 1 a.m. A similar result might be accomplished by limiting pay TV to certain specified nights such as Monday and/or Thursday. These arrangements would provide a substantial audience for advertiser-sponsored programming while permitting major pay TV productions an opportunity to gain sufficient viewers to make them profitable. Some additional requirements might provide sufficient competition to protect viewer interests. For example, pay TV producers might be required to provide a specified amount of nonpay TV programming that would be generally available. Furthermore, attainment of a specified fraction of the potential viewing audience of the free programming might be required in order that the pay TV broadcaster retain authority to offer programs. The second requirement would assure that the quality of the free programming remain high. If it did not, that is, if viewer surveys indicated that people did not watch it, then the pay TV producer would have strong incentive to improve his programming because of the threat to his license. This is an example of consumer feedback.

Free programming requirements could be changed in terms of time or audience penetration as a means of controlling the availability and quality of such programming. Free programming would compete with advertiser-sponsored programming or it might be advertiser-sponsored itself. The key factor is sampling users of free programming to measure its quality. The marketplace would set the level of quality of pay TV programming.

Telephone System

Because of the vast resources of capital, technology, manufacturing, and marketing, it is unrealistic to expect any meaningful competition in primary services supplied by the Bell System. The telephone industry has operated as a regulated monopoly for decades. By almost any standard of comparison, that operation has been highly successful and has led to an outstanding telephone service in this country--unquestionably the best in the world. Nevertheless, even though progress in telephone services has been continuous and substantial, it is not obvious that their development has been optimal.

In many ways the telephone companies operate as a benevolent monopoly. Meeting their customer needs is based on their judgment and evaluation of those needs and their decision as to whether those needs are being met appropriately at any particular time. Decisions to provide specific new services, for example, automatic fire alarms or automatic telephone answering, appear to be made with little weight given to consumer preferences other than whether such services would be marketable. Since there are more technologically feasible and marketable services than there are capital resources to provide them, the decision generally is not heavily weighted in terms of consumer preferences. Because of the monopolistic nature of the telephone system, the consumer has virtually no recourse if

he does not agree with the policies being pursued by the telephone company. The ineffectiveness of the regulatory action in controlling services is clearly evidenced by the great disparity between services different telephone companies supply to adjacent communities. A frequent complaint of non-Bell customers is that they have outdated and inadequate telephone services compared with what is already in service in a large part of the Bell System.

The question that must be addressed is whether or not it is possible to introduce into the telephone system a new force that will provide some of the desirable features of open competition in providing an input for customer preferences. FCC attempts to introduce competition have not been successful. Either the telephone company has chosen not to compete or to compete so strongly that it virtually overpowers the new entrant.

An example of noncompetition by the telephone company is the *Carterfone* decision discussed in Chapter 5. In this case the FCC ruled that apparatus not owned by the telephone company could be connected into the telephone system. After some attempt to have the ruling overturned in the courts, AT&T dropped its formal opposition. In some areas such as PBX exchanges, AT&T is attempting to preserve a competitive position but in most areas of foreign attachments the telephone company is making no attempt to compete. Thus, an essentially noncompetitive situation exists as far as the telephone company is concerned. One thing this means is that the vast engineering and manufacturing resources of AT&T will not be brought to bear on this area of technological development.

An example of the opposite reaction by the telephone company is the *MCI* decision also discussed in Chapter 5. In this case the FCC ruled that Microwave Communications, Inc., would be licensed to provide certain intercity data transmission

services not then available from the telephone company. Again, as in the *Carterfone* case, AT&T resisted this decision through court action. More importantly, however, AT&T undertook an accelerated research and development program to improve the range and quality of data transmission services that it could supply. Its development program was highly successful and it was able to supply a wide range of data transmission services at low costs--lower, in fact, than those for which MCI could provide the same services. There seems little doubt that the same, or equivalent, data transmission capabilities would eventually have been developed on a timetable established by the telephone company.

This particular intervention by the FCC altered that timetable and caused a reshuffling of substantial engineering and other resources by the Bell system. Whether, in the long run, this forced competition resulted in a net improvement of the telecommunications system or whether it just interchanged the timetable of certain of the services will be difficult to determine. However, it seems unlikely that the crash development of the data transmission capability is likely to have been as efficiently conducted as if it had been part of a more carefully planned program.

On the other hand, without the incentive introduced by competition from a new entrant, the reordering of priorities would not have occurred and data transmission costs would not have undergone the dramatic decrease that they did at that particular time. At best, the introduction of direct competition into markets dominated by the telephone companies appears to be of doubtful value. Some other technique must be employed to obtain the benefits equivalent to those resulting from competition without attempting to destroy the natural monopoly characteristics of telephony itself.

Synthetic Competition. In a free enterprise system competition among various corporations vying for a share of the market is expected. Variations in price, product or service characteristics, and marketing strategy will lead to preferential selection of customers. The product or service finding greatest acceptance with the customers will produce an imbalance in sales that will cause companies that are noncompetitive to alter their approach in such a manner as to make their product or service more attractive to prospective customers. Many situations arise that prevent the ideal operation of a competitive free enterprise system, and the automatic correction caused by feedback through customer selection may be absent. Such a situation occurs when a monopoly exists and a single company controls the diversity of products and services. This problem is particularly aggravated when the monopolist has sufficiently large resources to suppress competition by undercutting prices in areas where such competition is attempted. Under such conditions no significant competition can result and, therefore, customer preferences are given only minor weight in determining policies.

Recently, the FCC instituted a fact-finding proceeding with regard to the role of competition in the telecommunications industry.(15) With regard to this inquiry, AT&T offered the following comments(16):

1. Telecommunications services are most widely available at the lowest overall cost to the entire public and the country when those services are provided by regulated monopolies.

2. When competition is introduced in the telecommunications industry, it results in higher overall costs and in increased rates to exchange service users. These adverse effects on exchange users can be mitigated if existing carriers are allowed to compete on an equal basis.

3. The public interest will be most adversely affected--in terms of service availability, cost and quality--when telecommunications services are provided under a system of contrived competition or arbitrary market allocation.

These conclusions stem from the fact that the telecommunications industry displays economies of scale and the characteristics of a natural monopoly in the provision of services as a whole.

Theory suggests that since natural monopoly characteristics are present, the telecommunications field should hold little attraction for competitors. That would be true today if the industry had not followed pricing policies explicitly designed to attain the goal of universal service. This goal was made the law of the land in the Communications Act of 1934:

"...to make available so far as possible, to all the people of the United States, a rapid, efficient, Nation-wide and world-wide wire and radio communications service with adequate facilities at reasonable charges..."

Ironically the very success of the regulated telecommunications industry in reaching the goal of universal service at reasonable rates makes it vulnerable to selective competition, because this success has been achieved in great part through the application of value-of-service pricing and nationwide and statewide rate and cost averaging. This type of pricing, approved and even encouraged by regulators at both the state and federal levels, invites selective entry into those parts of the industry that can be served with the least cost and at the highest profit. Yet these are the very pricing policies that give the service its widest availability.

It appears that the telephone industry can make a very strong case to support its monopolistic position and it seems improbable that it will be

seriously threatened in the near future. Some alternative approach would seem indicated.

The FCC recently issued its decision regarding this major inquiry and found very little to criticize about the AT&T rate base or methods of operation. The agency did ask that AT&T justify some of its practice more precisely than had been done to date. However, the thrust of the commission's decision was that the services and the prices charged were excellent and reasonable, respectively. The arguments and evidence presented by the common carrier were apparently quite compelling when the commission gave them close scrutiny.

In situations where the possibility of free market competition does not exist, it would appear reasonable to attempt to achieve some of the desirable features of such competition by other means. Several possibilities appear to have sufficient promise to warrant further consideration. Two of the highly desirable primary benefits of competition are diversity of offerings allowing customer preference to be exhibited and pressure to keep prices low to increase the fraction of the market a particular company can capture. Because of the regulated nature of telecommunications, it may not be necessary to provide for price competition but rather to rely on price justification as is done now. If this is so, then the primary requirement would be some type of product and service diversity that would provide accurate customer preference feedback.

One method of generating customer-preference feedback in the telephone industry would be to require that a substantially increased range of services and equipments be made available to customers. These need not be made available to all users but might be provided in selected test or control regions. The results of such experiments would be required inputs to the regulatory agency for the approval of new or the adjustment of old

services. In this way customers would have a way of registering their preferences meaningfully--comparable in many ways to a competitive situation. Some thought would have to be given to the ways in which the various alternative services and devices would be selected. One approach might be the joint agency/industry development of a list of potential services and devices which must be made available to test groups of customers before such services are inaugurated in any sizeable way.

In keeping with any attempt to have the regulatory agency engage more actively in determining what technology will be developed, apparently some restructuring of the FCC should be done. Today the FCC consists of commissioners with legal backgrounds. The introduction of stronger technological and consumer-oriented voices on the commission would provide a more balanced approach to the problems inherent in any attempt to provide a simulated competitive situation for determining the directions of technological evolution.

Selective Competition. Another approach to providing competition-induced feedback of customers is to permit open competition in certain areas. Examples of this are foreign attachments to the telephone system, the supplying of private leased lines by special carriers, and paging services. In some developing areas competition also appears feasible. The most imminent is that of mobile telephone services. They could well be provided competitively within a single geographical area without any danger of damaging the integrity of the switched telephone system.

Other possibilities for direct competition might be developed from the lists of potential technological services and devices that are prepared for the simulated competition approach. Some of the proposed devices or services might be of no interest to the telephone company and, therefore, could be made available through open competition. In the

long run it may be that supplying the distribution, switching, and transmission of signals becomes the primary function of the telephone company while generation and use of the signals is the primary function of broad-based industrial competitive activities. If such services included the handling of wideband signals such as those of CATV and the full ramifications of the wired city, the magnitude of the physical plant and the capital investment involved would be of such proportions as to dwarf present telephone company investments.

Data Transmission

The transmission of information other than conventional radio, television, and voice signals is expanding at an enormous rate. This category of telecommunications called data transmission includes such things as airline reservations; accounting, inventory, and production control operations of companies; linking of computers at widely separated locations; and interrogation and response of remote data banks, ranging from credit ratings to criminal records. These will eventually include many presently undreamed of services. As we move toward a cashless society and an electronic postal service this kind of information will far exceed that handled by the conventional switched telephone system. Meanwhile, there is no way that data transmission systems can operate completely independently of the switched telephone system. This is because isolated users, such as retail outlets or individuals in their homes, need to be able to access the data transmission system in an economical manner, and this implies use of the already available telephone system.

The direction of future developments in this area is complex. Already, several highly divergent approaches are being employed in the development of data transmission systems. Common carriers, such as AT&T, have microwave and coaxial

cable systems suitable for both voice and data transmission; the specialized carriers such as MCI have dedicated microwave systems for data transmission; and a whole host of companies are developing satellite systems with multiple point-to-point data transmission capabilities.

AT&T takes the position that denying it the opportunity to offer data transmission services will unquestionably lead to substantially higher telephone rates due to loss of subsidies that data transmission services provide. Yet, it is clear that meaningful competition with common carriers in a situation where they have a guaranteed use of voice services is not possible. It would become impossible to tell which service was subsidizing the other.

Because of the anticipated growth in data transmission via satellites the inherent advantages that the common carriers have in already-installed ground-based microwave systems will no longer be very important. The data transmission requirements will overshadow the telephone usage in a few years and will be the dominant factor in the competitive situation. In the long run it appears that free competition for data transmission services via satellite may be a feasible approach to control of the marketplace. In such a case participation by the common carriers would be on an equal basis with other companies and they would not enjoy any special advantage because of their current responsibilities of providing low cost telephone services. It would be desirable for the large common carriers such as AT&T and GTE to enter this market because of the strong contributions their technical expertise would make to both quality and cost of service. However, their entry would be as an equal competitor rather than with any substantial advantage due to their telephone operation.

In the future, data transmission services will be as important a part of a nation's life blood

as the telephone is today. The same kind of precautions will have to be taken to assure continuity and reliability of service as is done now with the telephone. A major factor in such precautions may well be having available multiple, competing services that can interchange transmission capacity among each other. Many services such as banking, criminal data banks, military logistics, or air traffic control will require extraordinary reliability to avoid the disastrous results which could occur with loss of such services for even a short period of time. Other types of services of a more routine nature would be only slightly affected by short down-times for the systems. Careful planning will be required to insure intersystem compatibility and interconnectability. Regulatory and legal decisions made now will have lasting effects on how the data transmission services of the future develop and where the line is drawn between the natural monopoly of the switched telephone system and competitive data transmission services.

Conclusions

The development of telecommunications technology and its uses are strongly influenced by many factors discussed in earlier sections of this book. The rate of development and use, as well as the direction of evolution, depend on a wide variety of political forces and processes, in addition to economic variables which structure such development. In a major way these nontechnological considerations impinge on and control telecommunications development and growth. The results of this complex interplay depend upon which forces or factors dominate a particular issue or policy process that is crucial to the outcome. The FCC policies on cable TV illustrate the traditional pattern of protecting the status quo, while seeking to achieve an acceptable compromise with the

challenging interest on this issue. While this outcome is often the pattern that emerges from the political allocation process, it is not always the end result, as in the cases of *Carterfone* and *MCI* efforts to produce competition with the large common carriers. Certainly, the outcome is not pre-ordained in telecommunications issues.

Two general categories of efforts have been tried to achieve changes in the development of technology. The first involves the development of new entrants and challengers who seek to dislodge the established industry in a head-on confrontation in the political arenas. Challengers have tried this often, but with little success. Usually, the potent political power of the established groups dominates in such an encounter. The second category of efforts relates to changing either the institutions which make the allocations or changing the processes by which the allocative decisions are made.

What changes made in the processes or institutions seek to accomplish is to permit access to new groups of interests (e.g., consumers). Or they give new or different forces the ability to participate in decision-making, or even to control or dominate such decision-making. The success of such adjustments is never certain beforehand. However, given the existing processes and their results, certain changes in the FCC or in the other allocative processes could be made with fair certainty that particular problems would be eliminated. The objective of such institutional changes, however, is not just to alter structure. Rather, the purpose is to achieve different policies regarding the use and development of technology.

The discussions in this book illustrate the complexity of the forces and constraints operating to control developments in telecommunications. These forces and constraints are only partially understood and are themselves constantly changing

so that the process is dynamic from both the technological and the political point of view. A much better understanding of these processes will be required before any planned technological evolution can hope to succeed. Some FCC attempts to stimulate development in certain areas or to introduce competition indicate an awareness of the need for altering or influencing technological developments. However, until there is better understanding of the social, political, and technological factors in such processes there is little hope that they will accomplish their objectives.

An alternative procedure that has some promise is to cause innovations to be introduced in a manner that will provide feedback from users as well as suppliers so as to provide a self-stabilizing marketplace in the absence of price competition. Such a procedure permits acquisition of data based on actual user experience with various telecommunications services before large scale commitments of resources are made.

In some situations such as data transmission by satellite and dedicated surface transmission links it appears feasible to permit a competitive situation to develop. Where such data transmission operations provide services vital to the day-to-day welfare and safety of the public, it will be necessary to provide safeguards against catastrophic loss of services by requiring standardization of transmission formats and rerouting capabilities so that loss of some part of a system will not mean loss of data transmission capability.

Appendix

The purpose of this appendix is to present some of the exact wording which appears in various statutes, federal regulations, and court and FCC decisions relating to the regulation of telecommunications. This should give the interested reader an opportunity to see exactly what the "words" provide for in the various documents. Clearly, the words are not the only important dimensions of these documents, since their impacts reach far beyond the words. The interpretations placed on the documents by courts, the commission, and others clearly outline more fully than just the words what effect they will have.

Several explanatory notes should be provided here. Particular portions of these documents provide the basis for particular policies which have been discussed earlier in this book. For example, the All-Channel Receiver law is contained in § 303(s) of Title 47 of the *United States Code*. This brief paragraph forms the statutory authority for a small portion of the *Code of Federal Regulations* (§§ 15.65-15.68) which may have a profound effect on the development of UHF television broadcasting. The language of the Supreme Court in *Southwestern Cable*, while vague, provides the legal authority for all of § 76 of the *Code of Federal Regulations* dealing with cable television regulations, a small portion of which is reprinted in this appendix. The Communications Satellite Act of 1962 is contained in 47 U.S.C. §§ 701 ff. Although only portions of it are reprinted, they provide the essence of the statute creating an entire structure for development of the communications satellite industry. Where appropriate, the statutory wording is provided, and then either the regulation or court decision wording pertaining to particular parts of the statute are provided. In this way the reader can see how the commission or court has used the law, to develop a policy--at least in terms of wording.

The Communications Act of 1934 as Amended.

This statute is found in Title 47 of the *United States Code* (47 U.S.C.). Particular sections of this statute are presented here to give the reader a picture of the words authorizing the FCC to regulate wire and radio communications in this country.

§ *151. Purposes of chapter; Federal Communications Commission created*

For the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of the national defense, for the purpose of promoting safety of life and property through the use of wire and radio communication, and for the purpose of securing a more effective execution of this policy by centralizing authority heretofore granted by law to several agencies and by granting additional authority with respect to interstate and foreign commerce in wire and radio communication, there is created a commission to be known as the "Federal Communications Commission", which shall be constituted as hereinafter provided, and which shall execute and enforce the provisions of this chapter.

SUBCHAPTER II. COMMON CARRIERS

§ *201. Service and charges*

(a) It shall be the duty of every common carrier engaged in interstate or foreign communication by wire or radio to furnish such communication service upon reasonable request therefor; and, in accordance with the orders of the Commission, in cases where the Commission, after opportunity for hearing, finds such action necessary or desirable in the public interest, to establish physical connections with other carriers, to establish through routes and charges applicable thereto and the divisions of such charges, and to establish and provide facilities and regulations for operating such through routes.

(b) All charges, practices, classifications, and regulations for and in connection with such communication service, shall be just and reasonable, and any such charge, practice, classification, or regulation that is unjust or unreasonable is declared to be unlawful: *Provided,* That communications by wire or radio subject to this chapter may be classified into day, night, repeated, unrepeated, letter, commercial, press, Government, and such other classes as the Commission may decide to be just and reasonable, and different charges may be made for the different classes of communications: *Provided further,* That nothing in this chapter or in any other provision of law shall be construed to prevent a common carrier

subject to this chapter from entering into or operating under any contract with any common carrier not subject to this chapter, for the exchange of their services, if the Commission is of the opinion that such contract is not contrary to the public interest:

* * *

§ *205. Commission authorized to prescribe just and reasonable charges; penalties for violations*

(a) Whenever, after full opportunity for hearing, upon a complaint or under an order for investigation and hearing made by the Commission on its own initiative, the Commission shall be of opinion that any charge, classification, regulation, or practice of any carrier or carriers is or will be in violation of any of the provisions of this chapter, the Commission is authorized and empowered to determine and prescribe what will be the just and reasonable charge or the maximum or minimum, or maximum and minimum, charge or charges to be thereafter observed, and what classification, regulation, or practice is or will be just, fair, and reasonable, to be thereafter followed, and to make an order that the carrier or carriers shall cease and desist from such violation to the extent that the Commission finds that the same does or will exist, and shall not thereafter publish, demand, or collect any charge other than the charge so prescribed, or in excess of the maximum or less than the minimum so prescribed, as the case may be, and shall adopt the classification and shall conform to and observe the regulation or practice so prescribed.

(b) Any carrier, any officer, representative, or agent of a carrier, or any receiver, trustee, lessee, or agent of either of them, who knowingly fails or neglects to obey any order made under the provisions of this section shall forfeit to the United States the sum of $1,000 for each offense. Every distinct violation shall be a separate offense, and in case of continuing violation each day shall be deemed a separate offense.

§ *301. License for radio communication or transmission of energy*

It is the purpose of this chapter, among other things, to maintain the control of the United States over all the channels of interstate and foreign radio transmission; and to provide for the use of such channels, but not the ownership thereof, by persons for limited periods of time, under licenses granted by Federal authority, and no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license. No person shall use or operate any apparatus for the transmission of energy or communications or signals by radio (a) from one place in any Territory or possession of the United States or in the District of Columbia to another place

in the same Territory, possession, or District; or (b) from any State, Territory, or possession of the United States, or from the District of Columbia to any other State, Territory, or possession of the United States; or (c) from any place in any State, Territory, or possession of the United States, or in the District of Columbia, to any place in any foreign country or to any vessel; or (d) within any State when the effects of such use extend beyond the borders of said State, or when interference is caused by such use or operation with the transmission of such energy, communications, or signals from within said State to any place beyond its borders, or from any place beyond its borders to any place within said State, or with the transmission or reception of such energy, communications, or signals from and/or to places beyond the borders of said State; or (e) upon any vessel or aircraft of the United States; or (f) upon any other mobile stations within the jurisdiction of the United States, except under and in accordance with this chapter and with a license in that behalf granted under the provisions of this chapter.

§ *303. Powers and duties of Commission*
Except as otherwise provided in this chapter, the Commission from time to time, as public convenience, interest, or necessity requires, shall--

(a) Classify radio stations;

(b) Prescribe the nature of the service to be rendered by each class of licensed stations and each station within any class;

(c) Assign bands of frequencies to the various classes of stations, and assign frequencies for each individual station and determine the power which each station shall use and the time during which it may operate;

(d) Determine the location of classes of stations or individual stations;

(e) Regulate the kind of apparatus to be used with respect to its external effects and the purity and sharpness of the emissions from each station and from the apparatus therein;

(f) Make such regulations not inconsistent with law as it may deem necessary to prevent interference between stations and to carry out the provisions of this chapter: *Provided, however,* That changes in the frequencies, authorized power, or in the times of operation of any station, shall not be made without the consent of the station licensee unless, after a public hearing, the Commission shall determine that such changes will promote public convenience or interest or will serve public necessity, or the provisions of this chapter will be more fully complied with;

(g) Study new uses for radio, provide for experimental uses of frequencies, and generally encourage the larger and more effective use of radio in the public interest;

(h) Have authority to establish areas or zones to be served by any station;

(i) Have authority to make special regulations applicable to radio stations engaged in chain broadcasting;

(j) Have authority to make general rules and regulations requiring stations to keep such records of programs, transmissions of energy, communications, or signals as it may deem desirable;

(k) Have authority to exclude from the requirements of any regulations in whole or in part any radio station upon railroad rolling stock, or to modify such regulations in its discretion;

(l) Have authority to prescribe the qualifications of station operators, to classify them according to the duties to be performed, to fix the forms of such licenses, and to issue them to such citizens or nationals of the United States as the Commission finds qualified, except that in issuing licenses for the operation of radio stations on aircraft the Commission may, if it finds that the public interest will be served thereby, waive the requirement of citizenship in the case of persons holding United States pilot certificates or in the case of persons holding foreign aircraft pilot certificates which are valid in the United States on the basis of reciprocal agreements entered into with foreign governments;

(m)(1) Have authority to suspend the license of any operator upon proof sufficient to satisfy the Commission that the licensee--

(A) has violated any provision of any Act, treaty, or convention binding on the United States, which the Commission is authorized to administer, or any such Act, treaty, or convention; or

(B) has failed to carry out a lawful order of the master or person lawfully in charge of the ship or aircraft on which he is employed; or

(C) has willfully damaged or permitted radio apparatus or installations to be damaged; or

(D) has transmitted superfluous radio communications or signals or communications containing profane or obscene words, language, or meaning, or has knowingly transmitted--

(1) false or deceptive signals or communications, or

(2) a call signal or letter which has not been assigned by proper authority to the station he is operating; or

(E) has willfully or maliciously interfered with any other radio communications or signals; or

(F) has obtained or attempted to obtain, or has assisted another to obtain or attempt to obtain, an operator's license by fraudulent means.

(2) No order or suspension of any operator's license shall take effect until fifteen days' notice in writing thereof, stating the cause for the proposed suspension, has been given to the operator licensee who may make written

application to the Commission at any time within said fifteen days for a hearing upon such order. The notice to the operator licensee shall not be effective until actually received by him, and from that time he shall have fifteen days in which to mail the said application. In the event that physical conditions prevent mailing of the application at the expiration of the fifteen-day period, the application shall then be mailed as soon as possible thereafter, accompanied by a satisfactory explanation of the delay. Upon receipt by the Commission of such application for hearing, said order of suspension shall be held in abeyance until the conclusion of the hearing which shall be conducted under such rules as the Commission may prescribe. Upon the conclusion of said hearing the Commission may affirm, modify, or revoke said order of suspension.

(n) Have authority to inspect all radio installations associated with stations required to be licensed by any Act or which are subject to the provisions of any Act, treaty, or convention binding on the United States, to ascertain whether in construction, installation, and operation they conform to the requirements of the rules and regulations of the Commission, the provisions of any Act, the terms of any treaty or convention binding on the United States, and the conditions of the license or other instrument of authorization under which they are constructed, installed, or operated.

(o) Have authority to designate call letters of all stations;

(p) Have authority to cause to be published such call letters and such other announcements and data as in the judgment of the Commission may be required for the efficient operation of radio stations subject to the jurisdiction of the United States and for the proper enforcement of this chapter;

(q) Have authority to require the painting and/or illumination of radio towers if and when in its judgment such towers constitute, or there is a reasonable possibility that they may constitute, a menace to air navigation.

(r) Make such rules and regulations and prescribe such restrictions and conditions, not inconsistent with law, as may be necessary to carry out the provisions of this chapter, or any international radio or wire communications treaty or convention, or regulations annexed thereto, including any treaty or convention insofar as it relates to the use of radio, to which the United States is or may hereafter become a party.

(s) Have authority to require that apparatus designed to receive television pictures broadcast simultaneously with sound be capable of adequately receiving all frequencies allocated by the Commission to television broadcasting when such apparatus is shipped in interstate commerce, or is imported from any foreign country into the United States, for sale or resale to the public.

§ *701. Congressional declaration of policy and purpose*

(a) The Congress declares that it is the policy of the United States to establish, in conjunction and in cooperation with other countries, as expeditiously as practicable a commercial communications satellite system, as part of an improved global communications network, which will be responsive to public needs and national objectives, which will serve the communication needs of the United States and other countries, and which will contribute to world peace and understanding.

(b) The new and expanded telecommunication services are to be made available as promptly as possible and are to be extended to provide global coverage at the earliest practicable date. In effectuating this program, care and attention will be directed toward providing such services to economically less developed countries and areas as well as those more highly developed, toward efficient and economical use of the electromagnetic frequency spectrum, and toward the reflection of the benefits of this new technology in both quality of services and charges for such services.

(c) In order to facilitate this development and to provide for the widest possible participation by private enterprise, United States participation in the global system shall be in the form of a private corporation, subject to appropriate governmental regulation. It is the intent of Congress that all authorized users shall have nondiscriminatory access to the system; that maximum competition be maintained in the provision of equipment and services utilized by the system; that the corporation created under this chapter be so organized and operated as to maintain and strengthen competition in the provision of communications services to the public; and that the activities of the corporation created under this chapter and of the persons or companies participating in the ownership of the corporation shall be consistent with the Federal antitrust laws.

(d) It is not the intent of Congress by this chapter to preclude the use of the communications satellite system for domestic communications services where consistent with the provisions of this chapter nor to preclude the creation of additional communications satellite systems, if required to meet unique governmental needs or if otherwise required in the national interest.

§ *721. Implementation of policy*

In order to achieve the objectives and to carry out the purposes of this chapter--

(a) the President shall--

(1) aid in the planning and development and foster the execution of a national program for the establishment and operation, as expeditiously as possible, of a commercial communications satellite system;

(2) provide for continuous review of all phases of the development and operation of such a system, including the activities of a communications satellite corporation authorized under subchapter III of this chapter;

(3) coordinate the activities of governmental agencies with responsibilities in the field of telecommunication, so as to insure that there is full and effective compliance at all times with the policies set forth in this chapter;

(4) exercise such supervision over relationships of the corporation with foreign governments or entities or with international bodies as may be appropriate to assure that such relationships shall be consistent with the national interest and foreign policy of the United States;

(5) insure that timely arrangements are made under which there can be foreign participation in the establishment and use of a communications satellite system;

(6) take all necessary steps to insure the availability and appropriate utilization of the communications satellite system for general governmental purposes except where a separate communications satellite system is required to meet unique governmental needs, or is otherwise required in the national interest; and

(7) so exercise his authority as to help attain coordinated and efficient use of the electromagnetic spectrum and the technical compatibility of the system with existing communications facilities both in the United States and abroad.

(b) the National Aeronautics and Space Administration shall--

(1) advise the Commission on technical characteristics of the communications satellite system;

(2) cooperate with the corporation in research and development to the extent deemed appropriate by the Administration in the public interest;

(3) assist the corporation in the conduct of its research and development program by furnishing to the corporation, when requested, on a reimbursable basis, such satellite launching and associated services as the Administration deems necessary for the most expeditious and economical development of the communications satellite system;

(4) consult with the corporation with respect to the technical characteristics of the communications satellite system;

(5) furnish to the corporation, on request and on a reimbursable basis, satellite launching and associated services required for the establishment, operation, and maintenance of the communications satellite system approved by the Commission; and

(6) to the extent feasible, furnish other services, on a reimbursable basis, to the corporation in connection with the establishment and operation of the system.

(c) the Federal Communications Commission, in its administration of the provisions of the Communications Act of 1934, as amended, and as supplemented by this chapter, shall--

(1) insure effective competition, including the use of competitive bidding where appropriate, in the procurement by the corporation and communications common carriers of apparatus, equipment, and services required for the establishment and operation of the communications satellite system and satellite terminal stations; and the Commission shall consult with the Small Business Administration and solicit its recommendations on measures and procedures which will insure that small business concerns are given an equitable opportunity to share in the procurement program of the corporation for property and services, including but not limited to research, development, construction, maintenance, and repair.

(2) insure that all present and future authorized carriers shall have nondiscriminatory use of, and equitable access to, the communications satellite system and satellite terminal stations under just and reasonable charges, classifictions, practices, regulations, and other terms and conditions and regulate the manner in which available facilities of the system and stations are allocated among such users thereof;

(3) in any case where the Secretary of State, after obtaining the advice of the Administration as to technical feasibility, has advised that commercial communication to a particular foreign point by means of the communications satellite system and satellite terminal stations should be established in the national interest, institute forthwith appropriate proceedings under section 214(d) of this title to require the establishment of such communication by the corporation and the appropriate common carrier or carriers;

(4) insure that facilities of the communications satellite system and satellite terminal stations are technically compatible and interconnected operationally with each other and with existing communications facilities;

(5) prescribe such accounting regulations and systems and engage in such ratemaking procedures as will insure that any economies made possibly by a communications satellite system are appropriately reflected in rates for public communication services;

(6) approve technical characteristics of the operational communications satellite system to be employed by the corporation and of the satellite terminal stations; and

(7) grant appropriate authorizations for the construction and operation of each satellite terminal station; either to the corporation or to one or more authorized carriers or to the corporation and one or more such carriers jointly, as will best serve the public interest, convenience, and necessity the Commission shall authorize the

construction and operation of such stations by communications common carriers or the corporation, without preference to either;

(8) authorize the corporation to issue any shares of capital stock, except the initial issue of capital stock referred to in section 734(a) of this title, or to borrow any moneys, or to assume any obligation in respect of the securities of any other person, upon a finding that such issuance, borrowing, or assumption is compatible with the public interest, convenience, and necessity and is necessary or appropriate for or consistent with carrying out the purposes and objectives of this chapter by the corporation;

(9) insure that no substantial additions are made by the corporation or carriers with respect to facilities of the system or satellite terminal stations unless such additions are required by the public interest, convenience, and necessity;

(10) require, in accordance with the procedural requirements of section 214 of this title, that additions be made by the corporation or carriers with respect to facilities of the system or satellite terminal stations where such additions would serve the public interest, convenience, and necessity; and

(11) make rules and regulations to carry out the provisions of this chapter.

§ 735. *Powers of corporation; specific activities of corporation; possession of usual powers of stock corporation*

(a) In order to achieve the objectives and to carry out the purposes of this chapter, the corporation is authorized to--

(1) plan, initiate, construct, own, manage, and operate itself or in conjunction with foreign governments or business entities a commercial communications satellite system;

(2) furnish, for hire, channels of communication to United States communications common carriers and to other authorized entities, foreign and domestic; and

(3) own and operate satellite terminal stations when licensed by the Commission under section 721(c)(7) of this title.

(b) Included in the activities authorized to the corporation for accomplishment of the purposes indicated in subsection (a) of this section, are, among others not specifically named--

(1) to conduct or contract for research and development related to its mission;

(2) to acquire the physical facilities, equipment and devices necessary to its operations, including communications satellites and associated equipment and facilities, whether by construction, purchase, or gift;

(3) to purchase satellite launching and related services from the United States Government;

(4) to contract with authorized users, including the United States Government, for the services of the communications satellite system; and

(5) to develop plans for the technical specifications of all elements of the communications satellite system.

(c) To carry out the foregoing purposes, the corporation shall have the usual powers conferred upon a stock corporation by the District of Columbia Business Corporation Act.

U.S. v. Southwestern Cable Co.

In this case the Supreme Court held that the FCC had jurisdiction to regulate CATV systems. Footnotes and various citations have been removed from the Court opinion.

OPINION OF THE COURT

Mr. Justice Harlan delivered the opinion of the Court.

These cases stem from proceedings conducted by the Federal Communications Commission after requests by Midwest Television for relief under §§ 74.1107 and 74.1109 of the rules promulgated by the Commission for the regulation of community antenna television (CATV) systems. Midwest averred that respondents' CATV systems transmitted the signals of Los Angeles broadcasting stations into the San Diego area, and thereby had, inconsistently with the public interest, adversely affected Midwest's San Diego station. Midwest sought an appropriate order limiting the carriage of such signals by respondents' systems. After consideration of the petition and of various responsive pleadings, the Commission restricted the expansion of respondents' service in areas in which they had not operated on February 15, 1966, pending hearings to be conducted on the merits of Midwest's complaints.

On petitions for review, the Court of Appeals for the Ninth Circuit held that the Commission lacks authority under the Communications Act of 1934, 48 Stat 1064, 47 USC § 151, to issue such an order. 378 F2d 118. We granted certiorari to consider this important question of regulatory authority.

For reasons that follow, we reverse.

* * *

II.

We must first emphasize that questions as to the validity of the specific rules promulgated by the Commission for the regulation of CATV are not now before the Court. The issues in these cases are only two: whether the Commission has authority under the Communications Act to regulate CATV systems, and, if it has, whether it has, in addition, authority to issue the prohibitory order here in question.

The Commission's authority to regulate broadcasting and other communications is derived from the Communications Act

of 1934, as amended. The Act's provisions are explicitly applicable to "all interstate and foreign communication by wire or radio . . . ." 47 USC § 152(a). The Commission's responsibilities are no more narrow: it is required to endeavor to "make available . . . to all the people of the United States a rapid, efficient, Nation-wide, and world-wide and radio communication service . . . ." 47 USC § 151. The Commission was expected to serve as the "single Government agency" with "unified jurisdiction" and "regulatory power over all forms of electrical communication, whether by telephone, telegraph, cable, or radio." It was for this purpose given "broad authority." As this Court emphasized in an earlier case, the Act's terms, purposes, and history all indicate that Congress "formulated a unified and comprehensive regulatory system for the (broadcasting) industry."

* * *

Respondents do not suggest that CATV systems are not within the term "communication by wire or radio." Indeed, such communications are defined by the Act so as to encompass "the transmission of . . . signals, pictures, and sounds of all kinds," whether by radio or cable, "including all instrumentalities, facilities, apparatus, and services (among other things, the receipt, forwarding, and delivery of communications) incidental to such transmission." 47 USC §§ 153(a), (b). These very general terms amply suffice to reach respondents' activities.

Nor can we doubt that CATV systems are engaged in interstate communication, even where, as here, the intercepted signals emanate from stations located within the same State in which the CATV system operates. We may take notice that television broadcasting consists in very large part of programming devised for, and distributed to, national audiences; respondents thus are ordinarily employed in the simultaneous retransmission of communications that have very often originated in other States. The stream of communication is essentially uninterrupted and properly indivisible. To categorize respondents' activities as intrastate would disregard the character of the television industry, and serve merely to prevent the national regulation that "is not only appropriate but essential to the efficient use of radio facilities."

* * *

Nonetheless, respondents urge that the Communications Act, properly understood, does not permit the regulation of CATV systems. First, they emphasize that the Commission in 1959 and again in 1966 sought legislation that would have explicitly authorized such regulation, and that its efforts were unsuccessful. In the circumstances here, however, this cannot be dispositive. The Commission's requests for legislation evidently reflected in each instance both its uncertainty as to the proper width of its authority and its understandable

preference for more detailed policy guidance than the Communications Act now provides. We have recognized that administrative agencies should, in such situations, be encouraged to seek from Congress clarification of the pertinent statutory provisions.

* * *

Nor can we obtain significant assistance from the various expressions of congressional opinion that followed the Commission's requests. In the first place, the views of one Congress as to the construction of a statute adopted many years before by another Congress have "very little, if any, significance."

* * *

Further, it is far from clear that Congress believed, as it considered these requests for legislation, that the Commission did not already possess regulatory authority over CATV. In 1959, the proposed legislation was preceded by the Commission's declarations that it "did not intend to regulate CATV," and that it preferred to recommend the adoption of legislation that would impose specified requirements upon CATV systems. Congress may well have been more troubled by the Commission's unwillingness to regulate than by any fears that it was unable to regulate. In 1966, the Commission informed Congress that it desired legislation in order to "confirm (its) jurisdiction and to establish such basic national policy as (Congress) deems appropriate." HR Rep No. 1635, 89th Cong, 2d Sess, 16. In response, the House Committee on Interstate and Foreign Commerce said merely that it did not "either agree or disagree" with the jurisdictional conclusions of the Second Report, and that "the question of whether or not . . . the Commission has authority under present law to regulate CATV systems is for the courts to decide . . . ." Id., at 9. In these circumstances, we cannot derive from the Commission's requests for legislation anything of significant bearing on the construction question now before us.

Second, respondents urge that § 152(a) does not independently confer regulatory authority upon the Commission, but instead merely prescribes the forms of communications to which the Act's other provisions may separately be made applicable. Respondents emphasize that the Commission does not contend either that CATV systems are common carriers, and thus within Title II of the Act, or that they are broadcasters, and thus within Title III. They conclude that CATV, with certain of the characteristics both of broadcasting and of common carriers, but with all of the characteristics of neither, eludes altogether the Act's grasp.

We cannot construe the Act so restrictively. Nothing in the language of § 152(a), in the surrounding language, or in the Act's history or purposes limits the Commission's authority to those activities and forms of communication that are specifically described by the Act's other provisions. The section it-

self states merely that the "provisions of (the Act) shall apply to all interstate and foreign communication by wire or radio . . . ." Similarly, the legislative history indicates that the Commission was given "regulatory power over all forms of electrical communication . . . ." S Rep No. 781, 73d Cong, 2d Sess, 1. Certainly Congress could not in 1934 have foreseen the development of community antenna television systems, but it seems to us that it was precisely because Congress wished "to maintain, through appropriate administrative control, a grip on the dynamic aspects of radio transmission," that it conferred upon the Commission a "unified jurisdiction" and "broad authority." Thus, "(u)nderlying the whole (Communications Act) is recognition of the rapidly fluctuating factors characteristic of the evolution of broadcasting and of the corresponding requirement that the administrative process possess sufficient flexibility to adjust itself to these factors."

* * *

Congress in 1934 acted in a field that was demonstrably "both new and dynamic," and it therefore gave the Commission "a comprehensive mandate," with "not niggardly but expansive powers."

* * *

We have found no reason to believe that § 152 does not, as its terms suggest, confer regulatory authority over "all interstate . . . communication by wire or radio."

Moreover, the Commission has reasonably concluded that regulatory authority over CATV is imperative if it is to perform with appropriate effectiveness certain of its other responsibilities. Congress has imposed upon the Commission the "obligation of providing a widely dispersed radio and television, service," with a "fair, efficient, and equitable distribution" of service among the "several States and communities." 47 USC § 307(b). The Commission has, for this and other purposes, been granted authority to allocate broadcasting zones or areas, and to provide regulations "as it may deem necessary" to prevent interference among the various stations. 47 USC §§ 303(f), (h). The Commission has concluded, and Congress has agreed, that these obligations require for their satisfaction the creation of a system of local broadcasting stations, such that "all communities of appreciable size (will) have at least one television station as an outlet for local self-expression." In turn, the Commission has held that an appropriate system of local broadcasting may be created only if two subsidiary goals are realized. First, significantly wider use must be made of the available ultra-high-frequency channels. Second, communities must be encouraged "to launch sound and adequate programs to utilize the television channels now reserved for educational purposes." These subsidiary goals have received the endorsement of Congress.

The Commission has reasonably found that the achievement of each of these purposes is "placed in jeopardy by the unregulated explosive growth of CATV." HR Rep No. 1635, 89th Cong, 2d Sess, 7. Although CATV may in some circumstances make possible "the realization of some of the (Commission's) most important goals,"

* * *

its importation of distant signals into the service areas of local stations may also "destroy or seriously degrade the service offered by a television broadcaster," id., at 700, and thus ultimately deprive the public of the various benefits of a system of local broadcasting stations. In particular, the Commission feared that CATV might, by dividing the available audiences and revenues, significantly magnify the characteristically serious financial difficulties of UHF and educational television broadcasters. The Commission acknowledged that it could not predict with certainty the consequences of unregulated CATV, but reasoned that its statutory responsibilities demand that it "plan in advance of foreseeable events, instead of waiting to react to them."

We are aware that these consequences have been variously estimated, but must conclude that there is substantial evidence that the Commission cannot "discharge its overall responsibilities without authority over this important aspect of television service." Staff of Senate Comm on Interstate and Foreign Commerce, 85th Cong, 2d Sess, The Television Inquiry: The Problem of Television Service for Smaller Communities 19 (Comm Print 1959).

The Commission has been charged with broad responsibilities for the orderly development of an appropriate system of local television broadcasting. The significance of its efforts can scarcely be exaggerated, for broadcasting is demonstrably a principal source of information and entertainment for a great part of the Nation's population. The Commission has reasonably found that the successful performance of these duties demands prompt and efficacious regulation of community antenna television systems. We have elsewhere held that we may not, "in the absence of compelling evidence that such was Congress' intention . . . prohibit administrative action imperative for the achievement of any agency's ultimate purposes."

* * *

There is no such evidence here, and we therefore hold that the Commission's authority over "all interstate . . . communication by wire or radio" permits the regulation of CATV systems.

There is no need here to determine in detail the limits of the Commission's authority to regulate CATV. It is enough to emphasize that the authority which we recognize today under § 152(a) is restricted to that reasonably ancillary to the effective performance of the Commission's various responsibili-

ties for the regulation of television broadcasting. The Commission may, for these purposes, issue "such rules and regulations and prescribe such restrictions and conditions, not inconsistent with law," as "public convenience, interest, or necessity requires." 47 USC § 303(r). We express no views as to the commission's authority, if any, to regulate CATV under any other circumstances or for any other purposes.

* * *

FCC Regulations

What follows are selected portions of the regulations formulated by the Federal Communications Commission in response to the All-Channel Receiver Act and the *Southwestern Cable* decision. These are found in 47 C.F.R. at the appropriate section indicated in the excerpt.

§ *15.65 All-channel television broadcast reception: General requirement.*

Except as provided in § 15.66, all television broadcast receivers manufactured after April 30, 1964, and shipped in interstate commerce or imported from any foreign country into the United States, for sale or resale to the public, shall be capable of adequately receiving all channels allocated by the Commission to the television broadcast service. A television broadcast receiver is capable of adequately receiving all channels if it meets the requirements of §§ 15.67 and 15.68 in effect on the day of its manufacture.

§ *15.67 All-channel television broadcast reception: Receivers manufactured after April 30, 1964.*

Television broadcast receivers manufactured after April 30, 1964, shall comply with the following specifications:

(a) *Noise figure.* The noise figure for any television channel between 14 and 83 inclusive, shall not be larger than 18 db.

(b) *Peak picture sensitivity.* The peak picture sensitivity of any television broadcast receiver, average for all channels between 14 and 83 inclusive, shall not be more than 8 db larger than the peak picture sensitivity of that receiver averaged for all television channels between 2 and 13 inclusive. (35 F.R. 2666, Feb. 6, 1970)

§ *15.68 All-channel television broadcast reception: Receivers manufactured on or after July 1, 1971.*

(a) *Effective date.* The requirements of this section, in addition to the requirements of § 15.67, shall apply to 10 percent of the television receiver models produced by any domestic manufacturer, or exported to the United States by any foreign manufacturer, on or after July 1, 1971; 40 percent of the models produced (or exported to the United States) by any manufacturer on or after July 1, 1972; 70 percent of the models

produced (or exported to the United States) by any manufacturer on or after July 1, 1973; and to all receivers manufactured (or exported to the United States) on or after July 1, 1974. They shall, in addition, apply to any receiver model manufactured (or exported to the United States) on or after January 1, 1972, and not manufactured prior to that date.

Note: The term "model" refers to all of a type of television broadcast receiver made (or exported to the United States) by a single manufacturer which combines the same basic chassis with the same size picture tube. To determine the number of models subject to the requirements on the interim compliance dates, multiply the total number of models by the appropriate percentage and reduce the result to the next lowest whole number.

(b) *Receiver requirements.* On a given receiver (after any initial adjustment of a detent mechanism required to receive UHF channels), use of the UHF and VHF tuning systems shall provide approximately the same degree of tuning accuracy with approximately the same expenditure of time and effort.

(1) *Basic tuning mechanism.* If any television receiver is equipped to provide for repeated access to VHF television channels at discrete tuning positions, that receiver shall be equipped to provide for repeated access to a minimum of six UHF television channels at discrete tuning positions. Unless a discrete tuning position is provided for each channel allocated to UHF television, each position shall be readily adjustable to a particular UHF channel by the user without the use of tools. If 12 or fewer discrete tuning positions are provided, each position shall be adjustable to receive any channel allocated to UHF television.

Note: The combination of detented rotary switch and pushbutton controls is acceptable, provided UHF channels, after their initial selection, can be accurately tuned with an expenditure of time and effort approximately the same as that used in accurately tuning VHF channels. A UHF tuning system comprising five pushbuttons and a separate manual tuning knob is considered to provide repeated access to six channels at discrete tuning positions. A one-knob (VHF-UHF) tuning system providing repeated access to 11 or more discrete tuning positions is also acceptable, provided each of the tuning positions is readily adjustable, without use of tools, to receive any UHF channel.

(2) *Tuning aids.* If equipment and controls which tend to simplify, expedite or perfect the reception of television signals (e.g., AFC, visual aids, remote control, or signal seeking capability, referred to generally as tuning aids) are incorporated into the design of a television broadcast receiver, tuning aids of the same type and of comparable capability and quality shall be provided for tuning both the VHF television channels and the UHF television channels.

(3) *Tuning controls and channel read-out.* UHF tuning controls and channel read-out on a given receiver shall be

comparable in size, location, accessibility and legibility to VHF tuning controls and readout on that receiver. If any television receiver utilizes continuous UHF tuning for any function (e.g., as the basic tuning mode, for presetting a detent mechanism for repeated access at discrete tuning positions, or for tuning a channel which cannot be assigned a discrete tuning position), that receiver shall be equipped to display the approximate UHF television channel the tuner has been positioned to receive. If any television receiver is equipped to provide repeated access to UHF television channels at discrete tuning positions, the manufacturer shall provide for the display of the precise UHF channel selected or shall provide to the user a means of identifying the precise channel selected without the use of tools: *Provided, however,* That the 70 UHF channel numbers may be displayed in groups of three or less at each of 24 settings, if

(i) The tuning mechanism uses a single control to select the VHF and UHF channels;

(ii) Any one of the three channels simultaneously displayed can be precisely tuned to the correct frequency; and

(iii) The reset accuracy (with AFC, if provided) is sufficient to eliminate the need for routine fine tuning.

(c) *Progress reports.* Television receiver manufacturers shall file periodic reports detailing their progress in meeting the requirements of this section. The reports shall be filed regularly, on June 1 and December 1 of each year, beginning on December 1, 1970, and shall be directed to the Office of Chief Engineer, Federal Communications Commission, Washington, D.C. 20554. Any manufacturer who expects to encounter difficulty in meeting the schedule for compliance shall, in addition, at the earliest possible date, file a special report detailing the difficulties encountered and the steps being taken to overcome them.

(d) *Use of a 70-position nonmemory UHF detent tuning system.*

(1) Numerical readout shall be provided for each of the 70 UHF channels, or, if all of the VHF and UHF channel numbers displayed are at all times visible on the face of the receiver, numerical readout shall be provided for at least every other UHF channel, with marks to indicate those channels not displayed numerically.

(2) Until July 1, 1975, a 70-position, nonmemory UHF detent tuning system may be used to meet the requirements of this section provided the channel selection mechanism shall be capable of positioning the tuner to receive each UHF channel at its designated detent position, with maximum deviation from correct frequency on any detent setting not exceeding ±3 MHz, when approached from either direction of rotation.

(3) On or after July 1, 1975, a 70-position nonmemory UHF detent tuning system may be used to meet the requirements of this section provided the channel selection mechanism shall be capable of positioning the tuner to receive each UHF channel at its designated detent position, with maximum deviation from correct frequency on any detent setting not exceeding ±2 MHz, when approached from either direction of rotation.

(4) On or after July 1, 1976, a 70-position nonmemory UHF detent tuning system may be used to meet the requirements of this section, providing either of the following two conditions is met:

(i) *For any television receiver (monochrome or color).* The need for routine fine tuning of UHF channels is eliminated.

Note: This requirement will be considered met in each of the following circumstances:

The receiver is provided with AFC and a channel selection mechanism that is capable of positioning the tuner to receive each UHF channel at its designated detent position with a maximum deviation from correct frequency on any detent setting not exceeding ±1 MHz, when approached from either direction of rotation.

The receiver is provided with AFC and a channel selection mechanism that is capable of positioning the tuner to receive each UHF channel at its designated detent position within the pull in range of the AFC, when approached from either direction of rotation.

The receiver is provided with any other tuning system that produces and maintains detented tuning accuracy of the same order as the above specified systems.

(ii) *For monochrome receivers only.* The UHF channel selection mechanism is capable of positioning the tuner to receive each UHF channel at its designated detent position, with maximum deviation from correct frequency on any detent setting not exceeding ±1 MHz, when approached from either direction of rotation.

§ *76.251 Minimum channel capacity; access channels.*

(a) No cable television system operating in a community located in whole or in part within a major television market, as defined in § 76.5, shall carry the signal of any television broadcast station unless the system also complies with the following requirements concerning the availability and administration of access channels:

(1) *Minimum channel capacity.* Each such system shall have at least 120 MHz of bandwidth (the equivalent of 20 television broadcast channels) available for immediate or potential use for the totality of cable services to be offered;

(2) *Equivalent amount of bandwidth.* For each Class I cable channel that is utilized, such system shall be capable of providing an additional channel, 6 MHz in width,

suitable for transmission of Class II or Class III signals (see § 76.5 for cable channel definitions);

(3) *Two-way communications.* Each such system shall maintain a plant having technical capacity for nonvoice return communications;

(4) *Public access channel.* Each such system shall maintain at least one specially designated, noncommercial public access channel available on a first-come, nondiscriminatory basis. The system shall maintain and have available for public use at least the minimal equipment and facilities necessary for the production of programing for such a channel. See also § 76.201;

(5) *Education access channel.* Each such system shall maintain at least one specially designated channel for use by local educational authorities;

(6) *Local government access channel.* Each such system shall maintain at least one specially designated channel for local government uses;

(7) *Leased access channels.* Having satisfied the origination cablecasting requirements of § 76.201, and the requirements of subparagraphs (4), (5), and (6) of this paragraph for specially designated access channels, such system shall offer other portions of its nonbroadcast bandwidth, including unused portions of the specially designated channels, for leased access services. However, these leased channel operations shall be undertaken with the express understanding that they are subject to displacement if there is a demand to use the channels for their specially designated purposes. On at least one of the leased channels, priority shall be given part-time users;

(8) *Expansion of access channel capacity.* Whenever all of the channels described in subparagraphs (4) through (7) of this paragraph are in use during 80 percent of the weekdays (Monday-Friday) for 80 percent of the time during any consecutive 3-hour period for 6 consecutive weeks, such system shall have 6 months in which to make a new channel available for any or all of the above-described purposes;

(9) *Program content control.* Each such system shall exercise no control over program content on any of the channels described in subparagraphs (4) through (7) of this paragraph; however, this limitation shall not prevent it from taking appropriate steps to insure compliance with the operating rules described in subparagraph (11) of this paragraph;

(10) *Assessment of costs.*

(i) From the commencement of cable television service in the community of such system until five (5) years after completion of the system's basic trunk line, the channels described in subparagraphs (5) and (6) of this paragraph shall be made available without charge.

(ii) One of the public access channels described in subparagraph (4) of this paragraph shall always be made available without charge, except that production costs may be assessed for live studio presentations exceeding 5 minutes. Such production costs and any fees for use of other public access channels shall be consistent with the goal of affording the public a low-cost means of television access;

(11) *Operating rules.*

(i) For the public access channel(s), such system shall establish rules requiring first-come nondiscriminatory access; prohibiting the presentation of: Any advertising material designed to promote the sale of commercial products or services (including advertising by or on behalf of candidates for public office); lottery information; and obscene or indecent matter (modeled after the prohibitions in §§ 76.213 and 76.215, respectively); and permitting public inspection of a complete record of the names and addresses of all persons or groups requesting access time. Such a record shall be retained for a period of 2 years.

(ii) For the educational access channel(s), such system shall establish rules prohibiting the presentation of: Any advertising material designed to promote the sale of commercial products or services (including advertising by or on behalf of candidates for public office); lottery information; and obscene or indecent matter (modeled after the prohibitions in §§ 76.213 and 76.215, respectively) and permitting public inspection of a complete record of the names and addresses of all persons or groups requesting access time. Such a record shall be retained for a period of 2 years.

(iii) For the leased channel(s), such system shall establish rules requiring first-come, nondiscriminatory access; prohibiting the presentation of lottery information and obscene or indecent matter (modeled after the prohibitions in §§ 76.213 and 76.215, respectively); requiring sponsorship identification (see § 76.221); specifying an appropriate rate schedule and permitting public inspection of a complete record of the names and addresses of all persons or groups requesting time. Such a record shall be retained for a period of 2 years.

(iv) The operating rules governing public access, educational, and leased channels shall be filed with the Commission within 90 days after a system first activates any such channels, and shall be available for public inspection at the system's offices. Except on specific authorization, or with respect to the operation of the local government access channel, no local entity shall prescribe any other rules concerning the number or man-

ner of operation of access channels; however, franchise specifications concerning the number of such channels for systems in operation prior to March 31, 1972, shall continue in effect.

(b) No cable television system operating in a community located wholly outside of all major television markets shall be required by a local entity to exceed the provisions concerning the availability and administration of access channels contained in paragraph (a) of this section. If a system provides any access programing, it shall comply with paragraph (a) (9), (10), and (11) of this section.

(c) The provisions of this section shall apply to all cable television systems that commence operations on or after March 31, 1972, in a community located in whole or in part within a major television market. Systems that commenced operations prior to March 31, 1972, shall comply on or before March 31, 1977: *Provided, however,* That, if such systems begin to provide any of the access services described above at an earlier date, they shall comply with paragraph (a)(9), (10), and (11) of this section at that time: *And provided, further,* That if such systems receive certificates of compliance to add television signals to their operations at an earlier date, pursuant to § 76.61(b) or (c), or § 76.63(a) (as it relates to § 76.61(b) or (c)), for each such signal added, such systems shall provide one (1) access channel in the following order of priority--(1) public access, (2) education access, (3) local government access, and (4) leased access--and shall comply with the appropriate requirements of paragraphs (a) (4)-(7) and (a) (9)-(11) of this section with respect thereto.

§ *76.51 Major television markets.*

For purposes of the cable television rules, the following is a list of the major television markets and their designated communities:

(a) First 50 major television markets:

(1) New York, N.Y.--Linden-Paterson, N.J.
(2) Los Angeles-San Bernardino-Corona-Fontant, Calif.
(3) Chicago, Ill.
(4) Philadelphia, Pa.-Burlington, N.J.
(5) Detroit, Mich.
(6) Boston-Cambridge-Worcester, Mass.
(7) San Francisco-Oakland-San Jose, Calif.
(8) Cleveland-Lorain-Akron, Ohio.
(9) Washington, D.C.
(10) Pittsburgh, Pa.
(11) St. Louis, Mo.
(12) Dallas-Fort Worth, Tex.
(13) Minneapolis-St. Paul, Minn.
(14) Baltimore, Md.
(15) Houston, Tex.
(16) Indianapolis-Bloomington, Ind.
(17) Cincinnati, Ohio-Newport, Ky.

(18) Atlanta, Ga.
(19) Hartford-New Haven-New Britain-Waterbury, Conn.
(20) Seattle-Tacoma, Wash.
(21) Miami, Fla.
(22) Kansas City, Mo.
(23) Milwaukee, Wis.
(24) Buffalo, N.Y.
(25) Sacramento-Stockton-Modesto, Calif.
(26) Memphis, Tenn.
(27) Columbus, Ohio.
(28) Tampa-St. Petersburg, Fla.
(29) Portland, Oreg.
(30) Nashville, Tenn.
(31) New Orleans, La.
(32) Denver, Colo.
(33) Providence, R.I.-New Bedford, Mass.
(34) Albany-Schenectady-Troy, N.Y.
(35) Syracuse, N.Y.
(36) Charleston-Huntington, W. Va.
(37) Kalamazoo-Grand Rapids-Muskegon-Battle Creek, Mich.
(38) Louisville, Ky.
(39) Oklahoma City, Okla.
(40) Birmingham, Ala.
(41) Dayton-Kettering, Ohio.
(42) Charlotte, N.C.
(43) Phoenix-Mesa, Ariz.
(44) Norfolk-Newport News-Portsmouth-Hampton, Va.
(45) San Antonio, Tex.
(46) Greenville-Spartanburg-Anderson, S.C.-Asheville, N.C.
(47) Greensboro-High Point-Winston Salem, N.C.
(48) Salt Lake City, Utah.
(49) Wilkes Barre-Scranton, Pa.
(50) Little Rock, Ark.

(b) Second 50 major television markets:

(51) San Diego, Calif.
(52) Toledo, Ohio.
(53) Omaha, Nebr.
(54) Tulsa, Okla.
(55) Orlando-Daytona Beach, Fla.
(56) Rochester, N.Y.
(57) Harrisburg-Lancaster-York, Pa.
(58) Texarkana, Tex.-Shreveport, La.
(59) Mobile, Ala.-Pensacola, Fla.
(60) Davenport, Iowa-Rock Island-Moline, Ill.
(61) Flint-Bay City-Saginaw, Mich.
(62) Green Bay, Wis.
(63) Richmond-Petersburg, Va.
(64) Springfield-Decatur-Champaign-Jacksonville, Ill.
(65) Cedar Rapids-Waterloo, Iowa.
(66) Des Moines-Ames, Iowa.
(67) Wichita-Hutchinson, Kans.
(68) Jacksonville, Fla.
(69) Cape Girardeau, Mo.-Paducah, Ky.-Harrisburg, Ill.
(70) Roanoke-Lynchburg, Va.
(71) Knoxville, Tenn.

(72) Fresno, Calif.
(73) Raleigh-Durham, N.C.
(74) Johnstown-Altoona, Pa.
(75) Portland-Poland Spring, Maine.
(76) Spokane, Wash.
(77) Jackson, Miss.
(78) Chattanooga, Tenn.
(79) Youngstown, Ohio.
(80) South Bend-Elkhart, Ind.
(81) Albuquerque, N. Mex.
(82) Fort Wayne-Roanoke, Ind.
(83) Peoria, Ill.
(84) Greenville-Washington-New Bern, N.C.
(85) Sioux Falls-Mitchell, S. Dak.
(86) Evansville, Ind.
(87) Baton Rouge, La.
(88) Beaumont-Port Arthur, Tex.
(89) Duluth, Minn.-Superior, Minn.(sic)
(90) Wheeling, W. Va.-Steubenville, Ohio.
(91) Lincoln-Hastings-Kearney, Nebr.
(92) Lansing-Onondaga, Mich.
(93) Madison, Wis.
(94) Columbus, Ga.
(95) Amarillo, Tex.
(96) Huntsville-Decatur, Ala.
(97) Rockford-Freeport, Ill.
(98) Fargo-Valley City, N.D.
(99) Monroe, La.-El Dorado, Ark.
(100) Columbia, S.C.

§ 76.57 *Provisions for systems operating in communities located outside of all major and smaller television markets.*

A cable television system operating in a community located wholly outside all major and smaller television markets, as defined in § 76.5, shall carry television broadcast signals in accordance with the following provisions:

(a) Any such cable television system may carry or, on request of the relevant station licensee or permittee, shall carry the signals of:

(1) Television broadcast stations within whose Grade B contours the community of the system is located, in whole or in part;

(2) Television translator stations with 100 watts or higher power serving the community of the system and, as to cable systems that commence operations or expand channel capacity after March 30, 1972, noncommercial educational translator stations with 5 watts or higher power serving the community of the system. In addition, any cable system may elect to carry the signal of any noncommercial educational translator station;

(3) Noncommercial educational television broadcast stations within whose specified zone the community of the system is located, in whole or in part;

(4) Commercial television broadcast stations that are significantly viewed in the community of the system. See § 76.54.

(b) In addition to the television broadcast signals carried pursuant to paragraph (a) of this section, any such cable television system may carry any additional television signals.

§ *76.59 Provisions for smaller television markets.*

A cable television system operating in a community located in whole or in part within a smaller television market, as defined in § 76.5, shall carry television broadcast signals only in accordance with the following provisions:

(a) Any such cable television system may carry or, on request of the relevant station licensee or permittee, shall carry the signals of:

(1) Television broadcast stations within whose specified zone the community of the system is located, in whole or in part;

(2) Noncommercial educational television broadcast stations within whose Grade B contours the community of the system is located, in whole or in part;

(3) Commercial television broadcast stations licensed to communities in other smaller television markets, within whose Grade B contours the community of the system is located, in whole or in part;

(4) Television broadcast stations licensed to other communities which are generally considered to be part of the same smaller television market (Example: Burlington, Vt.-Plattsburgh, N.Y., television market);

(5) Television translator stations with 100 watts or higher power serving the community of the system and, as to cable systems that commence operations or expand channel capacity after March 30, 1972, noncommercial educational translator stations with 5 watts or higher power serving the community of the system. In addition, any cable system may elect to carry the signal of any noncommercial educational translator station;

(6) Commercial television broadcast stations that are significantly viewed in the community of the system. See § 76.54.

(b) Any such cable television system may carry sufficient additional signals so that, including the signals required to be carried pursuant to paragraph (a) of this section, it can provide the signals of a full network station of each of the major national television networks, and of one independent television station: *Provided, however,* That, in determining how many additional signals may be carried, any authorized but not operating television broadcast station that, if operational, would be required to be carried pursuant to paragraph (a)(1) of this section, shall be considered to be operational for a peri-

od terminating 18 months after grant of its initial construction permit. The following priorities are applicable to the additional television signals that may be carried:

(1) *Full network stations.* A cable television system may carry the nearest full network stations or the nearest in-state full network stations;

Note: The Commission may waive the requirements of this subparagraph for good cause shown in a petition filed pursuant to § 76.7.

(2) *Independent station.* A cable television system may carry any independent television station: *Provided, however,* That if a signal of a station in the first 25 major television markets (see § 76.51(a)) is carried pursuant to this subparagraph, such signal shall be taken from one of the two closest such markets, where such signal is available.

Note: It is not contemplated that waiver of the provisions of this subparagraph will be granted.

(c) In addition to the noncommercial educational television broadcast signals carried pursuant to paragraph (a) of this section, any such cable television system may carry the signals of any noncommercial educational stations that are operated by an agency of the State within which the system is located. Such system may also carry any other noncommercial educational signals, in the absence of objection filed pursuant to § 76.7 by any local noncommercial educational station or State or local educational television authority.

(d) In addition to the television broadcast signals carried pursuant to paragraphs (a) through (c) of this section, any such cable television system may carry:

(1) Any television stations broadcasting predominantly in a non-English language; and

(2) Any television station broadcasting a network program that will not be carried by a station normally carried on the system. Carriage of such additional stations shall be only for the duration of the network programs not otherwise available, and shall not require prior Commission notification or approval in the certificating process.

(e) Where the community of a cable television system is wholly or partially within both one of the first 50 major television markets and a smaller television market, the carriage provisions for the first 50 major markets shall apply. Where the community of a system is wholly or partially within both one of the second 50 major television markets and a smaller television market, the carriage provisions for the second 50 major markets shall apply.

(37 F.R. 3278, Feb. 12, 1972, as amended at 37 F.R. 13867, July 14, 1972)

§ *76.61 Provisions for first 50 major television markets.* A cable television system operating in a community located in whole or in part within one of the first 50 major television markets listed in § 76.51(a) shall carry television broadcast signals only in accordance with the following provisions:

(a) Any such cable television system may carry, or on request of the relevant station licensee or permittee, shall carry the signals of:

(1) Television broadcast stations within whose specified zone the community of the system is located, in whole or in part: *Provided, however,* That where a cable television system is located in the designated community of a major television market, it shall not carry the signal of a television station licensed to a designated community in another major television market, unless the designated community in which the cable system is located is wholly within the specified zone (see § 76.5(f) of the station, except as otherwise provided in this section;

(2) Noncommercial educational television broadcast stations within whose Grade B contours the community of the system is located, in whole or in part;

(3) Television translator stations with 100 watts or higher power serving the community of the system and, as to cable systems that commence operations or expand channel capacity after March 30, 1972, noncommercial educational translator stations with 5 watts or higher power serving the community of the system. In addition, any cable system may elect to carry the signal of any noncommercial educational translator station;

(4) Television broadcast stations licensed to other designated communities of the same major television market (Example: Cincinnati, Ohio-Newport, Ky., television market);

(5) Commercial television broadcast stations that are significantly viewed in the community of the system. See § 76.54.

(b) Any such cable television system may carry sufficient additional signals so that, including the signals required to be carried pursuant to paragraph (a) of this section, it can provide the signals of a full network station of each of the major national television networks, and of three independent television stations; *Provided, however,* That in determining how many additional signals may be carried, any authorized but not operating television broadcast station that, if operational, would be required to be carried pursuant to paragraph (a)(1) of this section, shall be considered to be operational for a period terminating 18 months after grant of its initial construction permit. The following priorities are applicable to the additional television signals that may be carried:

(1) *Full network stations.* A cable television system may carry the nearest full network stations, or the nearest in-State full network stations;

Note: The Commission may waive the requirements of this subparagraph for good cause shown in a petition filed pursuant to § 76.7.

(2) *Independent stations.*

(i) For the first and second additional signals, if any, a cable television system may carry the signals of any independent television station: *Provided, however,* That if signals of stations in the first 25 major television markets (see § 76.51(a)) are carried pursuant to this subparagraph, such signals shall be taken from one or both of the two closest such markets, where such signals are available. If a third additional signal may be carried, a system shall carry the signal of any independent UHF television station located within 200 air miles of the reference point for the community of the system (see § 76.53), or, if there is no such station, either the signal of any independent VHF television station located within 200 air miles of the reference point for the community of the system, or the signal of any independent UHF television station.

Note: It is not contemplated that waiver of the provisions of this subparagraph will be granted.

(ii) Whenever, pursuant to Subpart F of this part, a cable television system is required to delete a television program on a signal carried pursuant to subdivision (i) of this subparagraph or paragraph (c) of this section, or a program on such a signal is primarily of local interest to the distant community (e.g., a local news or public affairs program), such system may, consistent with the program exclusivity rules of Subpart F of this part, substitute a program from any other television broadcast station. A program substituted may be carried to its completion, and the cable system need not return to its regularly carried signal until it can do so without interrupting a program already in progress.

(c) After the service standards specified in paragraph (b) of this section have been satisfied, a cable television system may carry two additional independent television broadcast signals, chosen in accordance with the priorities specified in paragraph (b)(2) of this section: *Provided, however,* That the number of additional signals permitted under this paragraph shall be reduced by the number of signals added to the system pursuant to paragraph (b) of this section.

(d) In addition to the noncommercial educational television broadcast signals carried pursuant to paragraph (a) of this section, any such cable television system may carry the signals of any noncommercial educational stations that are operated by an agency of the State within which the system is located. Such system may also carry any other noncommercial educational signals, in the absence of objection filed pursuant to § 76.7

by any local noncommercial educational system or State or local educational television authority.

(e) In addition to the television broadcast signals carried pursuant to paragraphs (a) through (d) of this section, any such cable television system may carry:

(1) Any television stations broadcasting predominantly in a non-English language; and

(2) Any television station broadcasting a network program that will not be carried by a station normally carried on the system. Carriage of such additional stations shall be only for the duration of the network programs not otherwise available, and shall not require prior Commission notification or approval in the certificating process.

(f) Where the community of a cable television system is wholly or partially within both one of the first 50 major television markets and another television market, the provisions of this section shall apply.

§ *76.63 Provisions for second 50 major television markets.*

(a) A cable television system operating in a community located in whole or in part within one of the second 50 major television markets listed in § 76.51(b) shall carry television broadcast signals only in accordance with the provisions of § 76.61, except that in paragraph (b) of § 76.61, the number of additional independent television signals that may be carried is two (2).

(b) Where the community of a cable television system is wholly or partially within both one of the second 50 major television markets and one of the first 50 major television markets, the carriage provisions for the first 50 major markets shall apply. Where the community of a system is wholly or partially within both one of the second 50 major television markets and a smaller television market, the provisions of this section shall apply.

FCC Decisions

The following are two of the Federal Communications Commission's decisions which have been discussed in this book. The excerpts do not include the entire decision and rationale but only the central issues and the commission's treatment of them.

BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of

Use of the Carterfone Device in Message Toll Telephone Service — *Docket No. 16942*

In the Matter of
Thomas F. Carter and Carter Electronics Corp., Dallas, Tex. (complainants), v. American Telephone and Telegraph Co., Associated Bell System Companies, Southwestern Bell Telephone Co., and General Telephone Co. of the Southwest (defendants)

Docket No. 17073

DECISION

(Adopted June 26, 1968)

BY COMMISSIONER JOHNSON FOR THE COMMISSION: COMMISSIONER LOEVINGER DID NOT PARTICIPATE IN THE DECISION OF THIS CASE.

This proceeding involves the application of American Telephone and Telegraph Co. tariffs to the use by telephone subscribers of the Carterfone.

The Carterfone is designed to be connected to a two-way radio at the base station serving a mobile radio system. When callers on the radio and on the telephone are both in contact with the base station operator, the handset of the operator's telephone is placed on a cradle in the Carterfone device. A voice control circuit in the Carterfone automatically switches on the radio transmitter when the telephone caller is speaking; when he stops speaking, the radio returns to a receiving condition. A separate speaker is attached to the Carterfone to allow the base station operator to monitor the conversation, adjust the voice volume, and hang up his telephone when the conversation has ended.

The Carterfone device, invented by Thomas F. Carter, has been produced and marketed by the Carter Electronics Corp., of which Mr. Carter is president, since 1959. From 1959 through 1966 approximately 4,500 Carterfones were produced and 3,500 sold to dealers and distributors throughout the United States and in foreign countries.

The defendant telephone companies, acting in accordance with their interpretation of tariff FCC No. 132, filed April 16, 1957, by American Telephone and Telegraph Co., advised their subscribers that the Carterfone, when used in conjunction with the subscriber's telephone, is a prohibited interconnecting device, the use of which would subject the user to the penalties provided in the tariff. The tariff provides that:

> No equipment, apparatus, circuit or device not furnished by the telephone company shall be attached to or connected with the facilities furnished by the telephone company, whether physically, by induction or otherwise. * * * (A fuller text is provided in appendix A.)

* * *

On October 20, 1966, the Commission on its own motion ordered that a public hearing be held to resolve "the question of the justness, reasonableness, validity, and effect of the tariff regulations and practices complained of," assigning

docket No. 16942. The following five specific issues were designated for hearing:

1. The nature and extent of the public need and demand for the use of the Carterfone device in connection with interstate or foreign message toll telephone service;

2. The effect of the use of the Carterfone device upon the operation of the telephone system used to provide interstate and foreign telephone message toll telephone services to the public or upon the employees and facilities of the telephone companies providing such services or upon the public in its use of such telephone system;

3. Whether the provisions of tariff FCC No. 132 filed by American Telephone and Telegraph Co. may properly be construed to prohibit any telephone user from attaching the Carterfone device to the facilities of the telephone companies for use in connection with interstate and foreign message toll telephone services;

4. If the aforesaid tariff provisions may properly be construed to prohibit telephone users from attaching the Carterfone device to the facilities of the telephone companies for use in connection with interstate or foreign message toll telephone services;

(a) Whether such regulations are, or will be, unjust and unreasonable and, therefore, unlawful within the meaning of section 201(b) of the Communications Act of 1934, as amended, or are, or will be unduly discriminatory or preferential in violation of section 202(a) of said Act;[1]

(b) Whether, in the light of facts developed in connection with the foregoing issues, the Commission, in accordance with the provisions of section 205 of the Act, should prescribe tariff regulations which will permit the use of the Carterfone device in connection with interstate and foreign toll telephone service and, if so, the kind of tariff regulations which should be prescribed;

5. If the aforesaid tariff regulations of the telephone companies may not properly be construed to prohibit telephone users from attaching the Carterfone device to the facilities of the telephone companies for use in connection with interstate or foreign message toll telephone services, what action, if any, should be taken by the Commission with respect thereto.

* * *

By order released March 8, 1967, the complaint was consolidated for hearing with docket No. 16942, and the following issues were added:

1. Whether, with respect to the period from February 6, 1957, to December 21, 1966, the regulations and practices of tariff FCC No. 132 of the American Telephone and Telegraph Co. were properly construed and applied to prohibit any telephone user from attaching the Carterfone device to the facilities of the telephone companies for use in connection with interstate and foreign message toll telephone service; and if so

2. Whether, during the aforesaid period, such regulations and practices were unjust and unreasonable, and therefore unlawful within the meaning of section 201(b) of the Communications Act of 1934, as amended, or were unduly discriminatory or preferential in violation of section 202(a) of said Act.

The examiner found that there was a need and demand for a device to connect the telephone landline system with mobile

radio systems which could be met in part by the Carterfone. He also found that the Carterfone had no material adverse effect upon use of the telephone system. He construed the tariff to prohibit attachment of the Carterfone whether or not it harmed the telephone system, and determined that future prohibition of its use would be unjust and unreasonable. He also found that it would be unduly discriminatory under section 202(a) of the Act, since the telephone companies permit the use of their own interconnecting devices. However, he did not find the tariff prohibitions to have been unlawful in the past, largely because the harmless nature of the Carterfone was not known to the telephone companies, and he did not find that a general prohibition against non-telephone company supplied interconnecting devices was unjust or unwise, because of the risk he saw of "serious harm to the heart of the nation's communications network."

We agree with and adopt the examiner's findings that the Carterfone fills a need and that it does not adversely affect the telephone system. They are fully supported by the record. We also agree that the tariff broadly prohibits the use of interconnection devices, including the Carterfone. Its provisions are clear as to this. Finally, in view of the above findings, we hold, as did the examiner, that application of the tariff to bar the Carterfone in the future would be unreasonable and unduly discriminatory. However, for the reasons to be given, we also conclude that the tariff has been unreasonable, discriminatory, and unlawful in the past, and that the provisions prohibiting the use of customer-provided interconnecting devices should accordingly be striken.

We hold that the tariff is unreasonable in that it prohibits the use of interconnecting devices which do not adversely affect the telephone system. See *Hush-A-Phone Corp.* v. *U.S.*, 99 U.S. App. D.C. 190, 193, 238 F. 2d 266, 269 (D.C. Cir., 1956), holding that a tariff prohibition of a customer supplied "foreign attachment" was "in unwarranted interference with the telephone subscriber's right reasonably to use his telephone in ways which are privately beneficial without being publicly detrimental." The principle of Hush-A-Phone is directly applicable here, there being no material distinction between a foreign attachment such as the Hush-A-Phone and an interconnection device such as the Carterfone, so far as the present problem is concerned. Even if not compelled by the Hush-A-Phone decision, our conclusion here is that a customer desiring to use an interconnecting device to improve the utility to him or both the telephone system and a private radio system should be able to do so, so long as the interconnection does not adversely affect the telephone company's operations or the telephone system's utility for others. A tariff which prevents this is unreasonable; it is also unduly discriminatory when, as here, the telephone company's own interconnecting equipment is approved for

use. The vice of the present tariff, here as in Hush-A-Phone, is that it prohibits the use of harmless as well as harmful devices.

A.T.&T. has urged that since the telephone companies have the responsibility to establish, operate and improve the telephone system, they must have absolute control over the quality, installation, and maintenance of all parts of the system in order effectively to carry out that responsibility. Installation of unauthorized equipment, according to the telephone companies, would have at least two negative results. First, it would divide the responsibility for assuring that each part of the system is able to function effectively and, second, it would retard development of the system since the independent equipment supplier would tend to resist changes which would render his equipment obsolete.

There has been no adequate showing that nonharmful interconnection must be prohibited in order to permit the telephone company to carry out its system responsibilities. The risk feared by the examiner has not been demonstrated to be substantial, and no reason presents itself why it should be. No one entity need provide all interconnection equipment for our telephone system any more than a single source is needed to supply the parts for a space probe. We are not holding that the telephone companies may not prevent the use of devices which actually cause harm, or that they may not set up reasonable standards to be met by interconnection devices. These remedies are appropriate; we believe they are also adequate to fully protect the system.

Nor can we assume that the telephone companies would be hindered in improving telephone service by any tendency of the manufacturers and users of interconnection devices to resist change. The telephone companies would remain free to make improvements to the telephone system and could reflect any such improvements in reasonable revised standards for nontelephone company provided devices used in connection with the system. Manufacturers and sellers of such devices would then have the responsibility of offering for sale or use only such equipment as would be in compliance with such revised standards. An owner or user of a device which failed to meet reasonable revised standards for such devices, would either have to have the device rebuilt to comply with the revised standards or discontinue its use. Such is the risk inherent in the private ownership of any equipment to be used in connection with the telephone system.

* * *

Accordingly, we find that tariff FCC No. 263, paragraphs 2.6.1 and 2.6.9 are, and have since their inception been, unreasonable, unlawful and unreasonably discriminatory under

sections 201(b) and 202(a) of the Communications Act of 1934, as amended.

* * *

BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In Re Applications of	*Docket No. 16509*
Microwave Communications, Inc.	*File No. 4615-C1-P-64*
For Construction Permits To Establish New Facilities in the Domestic Public Point-to-Point Microwave Radio Service at Chicago, Ill., St. Louis, Mo., and Intermediate Points	*Dockets Nos. 16510, 16511, 16512, 16513, 16514, 16515, 16516, 16517, 16518, 16519*

DECISION

(Adopted August 13, 1969)

COMMISSIONER BARTLEY FOR THE COMMISSION: CHAIRMAN HYDE DISSENTING AND ISSUING A STATEMENT; COMMISSIONER ROBERT E. LEE DISSENTING AND ISSUING A STATEMENT IN WHICH COMMISSIONER WADSWORTH JOINS; COMMISSIONER JOHNSON CONCURRING AND ISSUING A SEPARATE STATEMENT.

1. This proceeding involves applications filed by Microwave Communications, Inc. (MCI), for construction permits for new facilities in the Domestic Public Point-to-Point Radio Service at Chicago, Ill., St. Louis, Mo., and nine intermediate points. MCI proposes to offer its subscribers a limited common carrier microwave radio service, designed to meet the interoffice and interplant communications needs of small business. Its subscribers would be able to lease microwave channels in varying bandwidths in increments of 2 kc. for either the entire length of its system or any segment thereof. For broadband users, channels may be leased in increments of 48, 250, and 1,000 kc. MCI, however, does not plan to provide its subscribers with a complete microwave service. The proposed service would be limited to transmission between MCI's microwave sites, making it incumbent upon each subscriber to supply his own communications link between MCI's sites and his place of business (loop service).

2. MCI contends that it will offer its subscribers substantially lower rates than those charged for similar services by the established carriers and that subscribers with less than full-time communication needs will be able to achieve additional savings through the channel sharing and half-time use provisions of its proposed tariff. Up to five subscribers will be permitted to share each channel on a party-line basis with a pro-rate reduction in rates. MCI will lease channels for half-time use between 6 a.m. and 6 p.m. with a 25-percent reduction in rates; and between 6 p.m. and 6 a.m. it proposes to combine the channels leased for half-time use into broadband channels of 48, 250, or 1,000 kc. for high-speed data transmission. MCI

further asserts that its proposed tariff contains fewer restrictions than those of the existing common carriers, so that greater flexibility of use will be possible, particularly with respect to channel bandwidth, splitting channels for voice and data transmissions, and in the attachment of customer equipment.

3. MCI's applications are opposed by Western Union Telegraph Co. (Western Union), General Telephone Co. of Illinois (General), and the Associated Bell System Cos., American Telephone & Telegraph Co., Illinois Bell Telephone Co., and Southwestern Bell Telephone Co. (Bell), which presently provide microwave services to the geographical area which MCI proposes to serve. In a memorandum opinion and order, F.C.C. 66-89, released February 8, 1966, and published in the Federal Register on February 11, 1966 (31 F.R. 2666), we designated the MCI applications for hearing on issues to determine inter alia: (a) whether the established common carriers offer services meeting the needs which MCI proposes to meet in the area which MCI proposes to serve; (b) whether the grant of MCI's applications would result in wasteful duplication of facilities; (c) whether MCI is financially qualified to construct and operate its proposed facilities; (d) whether there is a need for MCI's proposal; and (e) whether operation of MCI's proposed system would result in interference to existing common carrier services.

* * *

5. Upon release of the initial decision, we recognized that the questions raised at the hearing involved important policy considerations respecting the entry of new licensees into the communications common carrier field; and we directed by order, F.C.C. 67-1244, adopted November 14, 1967, that the initial decision be referred to the Commission for review. Bell, General, and Western Union each filed exceptions to the initial decision and requested oral argument. On April 30, 1968, we heard oral argument, en banc. We have considered the initial decision in light of the record, pleadings, and oral argument. Except as modified below and in the attached appendix, we adopt the hearing examiner's findings and conclusions.

6. The principal contentions advanced by Bell, General, and Western Union against the grant of MCI's applications are: (1) That MCI is not financially qualified to construct and operate the proposed facilities; (2) that no need has been shown for the common carrier services proposed; (3) that MCI will be unable to provide a reliable communications service; (4) that the proposal represents an inefficient utilization of the frequency spectrum; and (5) that the proposal is not technically feasible. Each of these contentions will be considered below.

MCI's Financial Qualifications

* * *

NEED FOR THE SERVICE

22. MCI is offering a service intended primarily for interplant and interoffice communications with unique and special-

ized characteristics. In these circumstances we cannot perceive how a grant of the authorizations requested would pose any serious threat to the established carriers' price averaging policies. Lower rates for the service offered is not the sole basis for our determination that MCI has demonstrated a need for the proposed facilities, but the flexibility available to subscribers, and the sharing and the part-time features of the proposal have been considered to be significant factors as well. The case of *WADS*, 35 F.C.C. 149 (1963), cited by Bell is therefore inapposite. Here the potential demand for the new service is not generated solely by reason of lower rates for a like service but because there is a "need for service which, if not met, would result in a serious deficiency in the communication services available to the public" (35 F.C.C. at 155). It may be, as the telephone companies and Western Union argue, that some business will be diverted from the existing carriers upon the grant of MCI's applications, but that fact provides no sufficient basis for depriving a segment of the public of the benefits of a new and different service.

23. Moreover, if we were to follow the carriers' reasoning and specify as a prerequisite to the establishment of a new common carrier service that it be so widespread as to permit cost averaging, we would in effect restrict the entry of new licensees into the common carrier field to a few large companies which are capable of serving the entire Nation. Such an approach is both unrealistic and inconsistent with the public interest. Innovations in the types and character of communications services offered or economics in operation which could not at once be instituted on a nationwide basis would be precluded from ever being introduced. In the circumstances of this case, we find the cream skimming argument to be without merit.

* * *

26. The conclusion that a public need exists for the services proposed by MCI is adequately supported by the evidence of record and we have relied solely upon that evidence in reaching our determination. Consequently, it is unnecessary to take official notice of A.T.&T.'s aforementioned statements or to place any reliance thereon in connection with the resolution of the public need issue; and we shall not do so. Nevertheless, we cannot ignore statements made by a party in filings with the Commission which contradict or are inconsistent with the position taken by that party in an adjudicatory proceeding. The statements by A.T.&T. in support of its own proposals substantially undermine the arguments advanced by the carrier in this proceeding to the effect that no public need exists for the sharing provisions of the MCI proposal and that MCI is cream-skimming. To the extent necessary to demonstrate the different positions taken by A.T.&T., we shall take official note of the statements made in support of its proposed tariff revisions.

Reliability of Service

* * *

30. Despite the strong protests of the existing carriers we are not persuaded that MCI's proposed equipment is technically deficient in any material respect. The sheds to be used for housing the equipment are waterproof and will afford sufficient protection against adverse weather for the microwave transmitting and receiving equipment which has an operational range from -30° to +50° C. While working conditions in the sheds in case of a breakdown would not be of the best, there is nothing in the record to justify a finding that they are not usable. It may be, as the carriers contend, that reliance upon generators instead of batteries is preferable. Nevertheless, it appears, that batteries will keep the system operational during periods of all but exceptionally extended power outages; and in that event the batteries will suffice until another power source is made available. We also find that MCI's arrangements for maintenance are adequate. By reason of the relatively limited size of its system, MCI will not employ a full-time maintenance staff and it would be uneconomical to do so. In lieu thereof, MCI has contracted with two firms, both of which are experienced in installing and maintaining private microwave systems, to periodically inspect the microwave facilities and to perform all necessary repair and maintenance work. Each microwave relay site will be equipped with a fault alarm connected to a 24-hour answering service which, in turn, will contact the appropriate maintenance company. These companies operate on a 24-hour basis and no tower site is located more than 106 miles from one of them. On the basis of this showing, we are satisfied that the steps proposed to be taken by MCI for maintenance and repair of its equipment should keep to a minimum any interruption in service resulting from equipment or power failure.

31. Western Union's criticism that the proposed system is deficient in that no provision is made for alternate routing in the event of damage or outage at any point on the system must be rejected as without merit. The alternate routes maintained by the major carriers serve also as primary routes for other cities and thus have a dual purpose. However, were MCI to construct an alternate route it would lie fallow except during periods of extended outages and such limited use would constitute a waste of frequencies which would not be in the public interest. MCI has available substitute towers and other equipment. It is prepared in case of outages to make repairs expeditiously and, with the possible exception of a major catastrophe, to resume operations with a minimum of delay.

Efficient Utilization of the Frequency Spectrum

32. We recognize, as the carriers argue, that MCI will not make the fullest possible use of the frequencies which it

seeks. MCI intends to use frequency diversity in the operation of its system, providing one protection channel for one working channel. Each MCI channel will have a maximum capacity of 960 circuits, but MCI anticipates an initial loading of between 45 and 75 circuits per channel and a maximum load of 300 circuits. In contrast, Bell uses two protection channels for six working channels, and it claims that each of its channels has a maximum capacity of 1,800 circuits. Even if Bell's systems do not achieve maximum loading, it clearly transmits a greater number of message circuits per channel than that contemplated by MCI.

33. In view of the limited frequencies available for common carrier use, the increasing demand for such frequencies, and the possibility that the grant of an application might limit a future assignment to a carrier which proposes a heavier loading or a better service, efficient utilization of the common carrier frequency spectrum by an applicant is a matter of serious concern to the Commission. In arriving at a public-interest determination in this case, we have therefore given careful consideration to the merits and demerits of MCI's proposed use of frequency diversity, its light loading, and other factors which go to efficient utilization of the common carrier portion of the frequency spectrum. With respect to MCI's proposed operation with frequency diversity, we note that the use of one protection channel for one working channel complies with existing policy. While the promulgation of rules to cover the use of frequency diversity is presently under consideration, adverse action on MCI's applications is not warranted for that reason. We do not know what provisions ultimately will be adopted and it may be that MCI's system will comply with the new rules, or that, with some minor adjustments, it can be brought into compliance.

34. Furthermore, in determining whether there is a frequency wastage we must take into account the benefits to be derived by the public from the proposed common carrier facilities, and to weigh these benefits against the disadvantages alleged by the opposing carriers. We have found that by reason of its low-cost, sharing, and part-time use provisions, MCI can reasonably be expected to furnish an economical microwave communications service to a segment of the public which presently cannot avail itself of such a service; and that its flexibility features will enable potential users to make more efficient use of their business equipment. These are substantial benefits which, in our view, outweigh the fact that MCI will not make the fullest possible use of its frequencies. When frequencies are used to meet a significant unfulfilled communications need, we do not believe that such use may be considered as "inefficient."

The Feasibility of Loop Service

35. The testimony of MCI's public witnesses and the findings of the Spindletop survey show that, in general, MCI's

potential subscribers have no interest in providing their own communications link between their facilities and MCI's transmitter sites. Therefore, MCI's ability to market its service will be dependent on the ability of its subscribers to secure loop service from the other common carriers serving the service area.

36. We are not unmindful of the fact that the carriers maintain that loop service is not technically feasible and that there is no provision for such service in their tariffs. However, insufficient evidence is contained in this record to support a conclusion that the proposed interconnection is not feasible, and we are not disposed to deny MCI's applications on the basis of the unsubstantiated allegations which have been advanced herein by the telephone companies and Western Union. What seems a more likely obstacle to interconnection is, as the hearing examiner indicated, the "carriers' intransigence, manifested in this case***." In these circumstances, the carriers are not in a position to argue that consideration of the interconnection question is premature. Since they have indicated that they will not voluntarily provide loop service we shall retain jurisdiction of this proceeding in order to enable MCI to obtain from the Commission a prompt determination on the matter of interconnection. Thus, at such time as MCI has customers and the facts and details of the customer's requirements are known, MCI may come directly to the Commission with a request for an order of interconnection. We have already concluded that a grant of MCI's proposal is in the public interest. We likewise conclude that, absent a significant showing that interconnection is not technically feasible, the issuance of an order requiring the existing carriers to provide loop service is in the public interest.

Summary

37. This is a very close case and one which presents exceptionally difficult questions. We have found MCI to be financially qualified but we realize that any unforeseen circumstances requiring a sizable expenditure may impair the applicant's financial capacity. We have found, based on the weight of the evidence, that there is a substantial likelihood that the communications of its subscribers will arrive promptly, in accurate form, and without extended interruptions due to failures in the system. We wish to make clear, therefore, that the findings and conclusions reached herein apply only to the frequencies specified, and for the areas described, in the applications now pending before us. Should MCI seek to obtain additional frequencies or to extend its microwave service to new areas, our action on its application will be based on a close scrutiny of its operations, the rules then governing the grant of applications for common carrier microwave frequencies and all other applicable policy considerations. Likewise, in connection with an application for renewal of license, we may

deny the application if circumstances so warrant or grant renewal on such conditions as we deem essential to insure that MCI's subscribers receive a reliable transmission service of acceptable quality. However, it would be inconsistent with the public interest to deny MCI's applications and thus deprive the applicant of an opportunity to demonstrate that its proposed microwave facilities will bring to its subscribers the substantial benefits which it predicts and which we have found to be supported by the evidence in this proceeding. We conclude, on the basis of the record as a whole, that the public interest will be served by a grant of MCI's application.

* * *

The Bell Bill

This is the wording of a proposed statute introduced in 1977 defining a policy to be followed regarding competition in the common carrier area of telecommunications. AT&T proposed the statute which clearly is a reaction to the MCI competitive threat.

95th Congress
1st Session
H. R. 8
IN THE HOUSE OF REPRESENTATIVES
January 4, 1977
A BILL

To reaffirm the intent of Congress with respect to the structure of the common carrier telecommunications industry rendering services in interstate and foreign commerce; to grant additional authority to the Federal Communications Commission to authorize mergers of carriers when deemed to be in the public interest; to reaffirm the authority of the States to regulate terminal and station equipment used for telephone exchange service; to require the Federal Communications Commission to make certain findings in connection with Commission actions authorizing specialized carriers; and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Consumer Communications Reform Act of 1977".

CONGRESSIONAL FINDINGS AND DECLARATION OF PURPOSE

SEC. 2. The Congress finds and declares that--

(a) The revenues from integrated interstate and foreign common carrier telecommunications services, based on charges reflecting both costs and value of service, have contributed toward meeting the costs of facilities used in common for providing such interstate and foreign services and local telephone exchange service throughout the United States, and thereby helped maintain a level of charges for telephone exchange service which is lower than otherwise would be required.

(b) The technical integrity of the nationwide telecommunications system, its coordinated planning, design, installation, improvement, management, operation and maintenance are indispensable elements in the interstate telecommunications network, necessary both to the reasonableness of charges and to the high quality and universality of common carrier telecommunications service, and accordingly Congress hereby reaffirms its policy that the integrated interstate telecommunications network shall be structured so as to assure widely available, high quality telecommunications services to all of the Nation's telecommunications users.

(c) The authorization of lines, facilities, or services of specialized carriers which duplicate the lines, facilities, or services of other telecommunications common carriers--

(1) involves higher charges for users of telephone exchange service by decreasing the interstate revenues that otherwise would be available for contribution to the common costs of providing telephone services throughout the United States;

(2) fosters inefficiencies in the utilization of national telecommunications resources through the creation of unnecessary and wasteful duplication of telecommunications lines and facilities and wasteful use of the radio spectrum;

(3) significantly impairs the technical integrity, the coordinated planning, design, installation, improvement, management, operation and maintenance of the integrated nationwide telecommunications network; and

(4) has an adverse impact on the national objectives of maintaining stability of consumer price levels, conserving national economic resources, improving productivity, and fostering an economy that will maintain adequate sources and reasonable costs of capital;

and is, therefore, contrary to the public interest.

(d) The Congress reaffirms its intent that the complete authority to regulate terminal and station equipment used for telephone exchange service shall rest with the States even though such terminal and station equipment also may be used in connection with interstate services.

(e) The congressional findings and declarations of policy set forth herein are necessary to achieve the purposes of the Communications Act of 1934 as specified in section 1 of that Act; and the Federal Communications Commission shall take no action inconsistent with the findings and declarations in this Act.

CHARGES FOR SERVICE

SEC. 3. Section 201(b) of the Communications Act of 1934, as amended (47 U.S.C. 201) is amended by adding the following at the end of the first sentence: "No compensatory charges for or in connection with such communication service may be found

to be unjust or unreasonable on the ground that it is too low. The Commission may not hold the charge of a carrier up to a particular level to protect the traffic or revenues from a communication service offered or provided by another carrier if such charge proposed by the carrier is compensatory. As used in this subsection, a charge is compensatory so long as it equals or exceeds the incremental cost of providing the communications service. Such incremental cost is the additional cost caused by the provision of the service including, where appropriate, the capital costs of whatever additional facilities are required to provide the service.".

ACQUISITIONS BY AND OF CERTAIN COMMON CARRIERS

SEC. 4. The Communications Act of 1934, as amended, is further amended by adding the following new section 224:

"SEC. 224. Upon application of any common carrier or other person involved in the transaction, the Commission shall have jurisdiction (i) to approve the acquisition of control by a domestic common carrier of any other domestic common carrier or the acquisition of the whole or any part of the property of a domestic common carrier by any other domestic common carrier, or (ii) to approve the acquisition by a person which is not a common carrier of control of any domestic common carrier or the acquisition of the whole or any part of the property of a domestic common carrier, whenever the Commission determines, after full opportunity for hearing on an evidentiary record, that such approval is in the public interest. The Commission shall give reasonable notice in writing concerning any such proposed action to the Governor of each of the States in which the physical property affected, or any part thereof, is situated, and to each State commission that may also have jurisdiction over any of the common carriers involved, and to such other persons as it may deem advisable, and shall afford such parties a reasonable opportunity to participate in any hearings related to such action. If the Commission approves the proposed acquisition, it shall certify to that effect; and thereupon any Act or Acts of Congress making the proposed acquisition unlawful shall not apply. As used in this section 224, 'domestic common carrier' shall mean a common carrier, the major portion of whose traffic and revenues is derived from communications services other than foreign communications. This section 224 shall not apply where either section 221(a) or 222 of this Act is applicable or to the acquisition by any person of a telephone common carrier as defined in section 225 (a)(1).".

SEC. 5. Section 2(b) of the Communications Act of 1934, as amended, (47 U.S.C. 152(b)) is further amended by striking the clause beginning with the words "except that" following the semicolon and inserting the following "except that sections 201 through 205 of this Act, both inclusive, and section 224

of this Act shall, except as otherwise provided therein, apply to carriers described in clauses (2), (3), and (4).".

REAFFIRMATION OF STATE JURISDICTION OVER LOCAL TERMINAL AND STATION EQUIPMENT

SEC. 6 Section 2(b) of the Communications Act of 1934, as amended (47 U.S.C. 152(b)) is further amended by striking "or" at the end of the phrase following "(1)" and substituting therefor the following: "including but not limited to, the charges, classifications, practices, services, facilities, or regulations for or in connection with the use or connection of any station equipment, terminating facilities, exchange plant, and other like instrumentalities and apparatus used in common for both intrastate communication service and interstate or foreign communication service, whether provided by a common carrier or any other person, or".

SEC. 7. Section 3 of the Communications Act of 1934, as amended (47 U.S.C. 153), is further amended by adding the following new subsection:

"(gg) 'Intrastate communication' means communication or transmission between points in the same State, territory, or possession of the United States, or in the District of Columbia, including among other things, all station equipment, terminating facilities, exchange plant, and other like instrumentalities and apparatus used for or in connection with telephone exchange service or interexchange service, even though such equipment, facilities, plant, instrumentalities or apparatus are or may be used in connection with interstate or foreign communications service. 'Intrastate communication service' means any service which provides intrastate communication.".

FINDINGS TO BE INCLUDED IN COMMISSION AUTHORIZATIONS OF SPECIALIZED CARRIERS

SEC. 8 The following new section is added in title II of the Communications Act of 1934, as amended:

"SEC. 225. (a) As used in this section--

"(1) The term 'telephone common carrier' means any common carrier, the major portion of whose traffic and revenues, in interstate and foreign communication and in intrastate communication, is derived from message telephone services, telephone exchange services, radio-telephone exchange services, or a combination thereof.

"(2) The term 'telegraph common carrier' means any common carrier which provides a public message telegram service in interstate communications.

"(3) The term 'specialized carrier' means any common carrier other than a telephone or telegraph common carrier.

"(4) The term 'message telephone service' means telephone service between stations in different exchange areas on a message-by-message basis, contemplating a separate connection for each occasion of use.

"(5) The term 'public message telegram service' means a substantially nationwide telegraph service for the transmission and reception of record matter where the transmission is not directly controlled by the sender and for which a charge is collected on the basis of number of words transmitted and which is available to the public.

"(b) The Commission shall not grant or authorize any construction, acquisition, or operation of any communication or transmission line or facility, or extension thereof, or any modification or renewal thereof, that otherwise might be granted or authorized pursuant to any provision of this Act, to any specialized carrier that furnishes or proposes to furnish interstate communication service unless the Commission shall find, after full opportunity for evidentiary hearing on the record, that such permit, license, or certificate, will not result in increased charges for telephone exchange service or in wasteful or unnecessary duplication of communication lines, facilities, equipment and instrumentalities of any telephone or telegraph common carrier, and will not significantly impair the technical integrity and capacity for unified and coordinated planning, management, design, and operation of the nationwide telephone network. In finding that such grant or authorization will not result in wasteful or unnecessary duplication, the Commission shall determine, among other things, that the proposed service or services of the specialized carrier, which are the subject of the requested grant or authorization, (i) are not like or similar to any service or services provided by a telephone or telegraph common carrier and (ii) cannot be provided by available communications lines, facilities, equipment, or instrumentalities of a telephone or telegraph common carrier. At any hearing involving a matter under this subsection, the burden of proof to support the requisite findings by the Commission shall be on the applicant for such permit, license, or certificate.".

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Glossary

Allocation. The process of distributing any resource among various claimants. Allocation can be done by economic processes such as the market place or political processes involving lobbying.

AM. Amplitude modulation.

AM broadcasting. Radiating into free space a radio wave carrying information in the form of amplitude modulation of the carrier. Transmission bandwidth is twice that of the modulating signal bandwidth.

Amplitude modulation. Process whereby the amplitude of a radio wave is varied in accordance with the amplitude of a second signal such as speech, music, or television.

Analog signal. Signal whose amplitude varies continuously as opposed to a signal that has been quantized and whose amplitude can only take on values from a discrete set of possible amplitudes.

Attenuation. Decrease in magnitude of amplitude or power during transmission of a signal from one point to another.

Bandwidth. The frequency interval outside of which the power spectrum of a signal is less than some specified fraction of its value at a reference frequency (usually the reference frequency is that at which the spectrum is a maximum). Measured in Hertz.

Bit. An abbreviation of BInary digiT. (1) Corresponds to the occurrence of (either) one of the characters of a language employing two different characters such as 0, 1 or mark, space. (2) Unit of information content equal to that of a message having an a priori probability of one half.

Broadband. An adjective used to describe signals that extend over a wide portion of the spectrum. For example, TV signals.

Carrier. A wave having characteristics that can be varied from a reference value by modulation.

Channel. A transmission path over which communication signals are sent.

COMSAT. The Communications Satellite Corporation created by an Act of Congress in 1962 to develop and operate the United States' portion of an international communications satellite system. It became the operating arm of the INTELSAT system when it became operational in 1964.

Cross-bar system. A telephone line switching system using cross-bar switches.

Data-Under-Voice. Technique for providing high-speed transmission of information in digital form using the lower portion of the frequency band in existing microwave networks not normally employed for voice transmission.

Echo. Name of an early experimental earth satellite consisting of a large metallized, inflated sphere used as a passive reflector for communication signals.

Electromagnetic wave. A wave characterized by variations of electric and magnetic fields. Radio waves.

ESS-1. Electronic Switching System being installed by Bell System.

F.C.C. Federal Communications Commission was created in 1934 to regulate wire and electromagnetic communication in the United States. This agency has jurisdiction over radio and television broadcasting, common carriers, cable television, and other interstate and international uses of the spectrum.

Frequency. The number of periods per second of a periodic function. Measured in units of hertz (Hz)--one cycle per second; kilohertz (kHz)--1,000 cycles per second; megahertz (MHz)--1,000,000 cycles per second; gigahertz (GHz)--1,000,000,000 cycles per second.

FM broadcasting. Radiating into free space a radio wave carrying information in the form of frequency modulation of the carrier.

Frequency division multiplexing. Process by which each of several modulating waveforms modulates a separate subcarrier and the subcarriers are spaced in frequency so that no two subcarriers occupy the same frequency band. Permits simultaneous transmission of several signals over the same channel.

Frequency modulation. Process whereby the frequency of a radio wave is varied in accordance with the amplitude of a second signal such as speech, music, or a binary coded signal. Transmission bandwidth is larger than the modulating signal bandwidth by a factor of five for FM broadcasting.

Geosynchronous orbit. Satellite orbit (altitude of 42,000 km or 22,300 mi) in which the satellite revolves around the earth at the same rate as the earth rotates (once each 24 hours). A geosynchronous satellite appears stationary above the earth's surface at some point along the equator.

Guard space. A blank segment of the spectrum located between adjacent channels in order to minimize interference between them.

IC. Integrated circuit.

Integrated circuit. A combination of interconnected circuit elements inseparably associated on or within a continuous substrate.

INTELSAT. The international satellite consortium formed in 1964 and in 1972 on a permanent basis to own and use the international communications satellite system. Member nations own shares and vote in proportion to their usage of the communications system. Earth stations are owned by the individual user countries. INTELSAT I, II, III, IV are the names and generation of the international communications satellites used to provide the services to member countries.

ITT. International Telephone and Telegraph is an international common carrier supplying communications services by radio satellite and undersea cable on a worldwide basis.

Large scale integration. Process whereby highly complex integrated circuits are fabricated.

Legislative oversight. The process of congressional investigation of a particular agency or administrative process by committee hearings and budget examinations. Although legislation doesn't result from this process, it is a central element of congressional control and influence over the administration of various policies and programs.

LSI. Large scale integration.

Modulation. Process by which certain characteristics of a carrier are varied in accordance with a modulating signal.

Microwave. Refers to the frequency range of electromagnetic radiation in which the wavelength is less than 30 cm (1 ft); i.e., upwards of 1,000 MHz.

Microwave relay. Intercity communication trunk in which signals are transmitted between towers 40 to 50 km (25-31 mi) apart.

Monopoly profits. The profits which can be earned by a monopolist when there is no competition for a market and the sole producer can charge whatever price he chooses. Such profits are those which exceed the profits obtainable in a competitive market setting where price is determined by supply of and demand for a product.

Multiplexing. Combining two or more signals into a single wave from which the individual signal can be recovered.

OTP. The Office of Telecommunications Policy was created by President Nixon in 1970 to provide advice and high level studies of current telecommunications policy issues.

PBX. Private branch exchange used by companies for internal distribution of telephone calls.

PCM. Pulse code modulation.

Pixel. Abbreviation for picture element. Smallest resolution element in a television picture.

Polarization diversity. Means of simultaneously transmitting two different signals on the same carrier by using two electromagnetic waves having their electric fields oriented at right angles to each other so they can be separated before detection.

President's Task Force on Telecommunication Policy. A special task force created by President Johnson in 1967 to examine various issues of telecommunications such as satellites, cable television, and domestic common carriers.

Pulse code modulation. A modulation process whereby a waveform is first converted from analog to digital form and the digital representation of the samples transmitted by a binary code.

Quantization. Process by which a continuous range of amplitudes is divided into a nonoverlapping set of subranges and to each subrange a unique value of the output is assigned.

RCA. Radio Corporation of America is an international common carrier. It is also engaged in domestic satellite programs, broadcast network operations, and the manufacture of electronic equipment.

RELAY. Early experimental communications satellite in low earth orbit (1962-64).

Sampling. Process of obtaining a sequence of instantaneous values of a waveform at regular intervals.

Signal-to-noise ratio. Relative power of the signal to that of the noise in a communication channel. High signal-to-noise ratio gives good transmission performance.

Single sideband transmission. A method of operation in which one of the two sidebands produced by amplitude modulation is suppressed. Transmission bandwidth equals modulating signal bandwidth.

Solid state. Adjective used to describe a device, circuit, or system whose operation depends on electrical phenomena occurring in a solid such as crystals of semiconductor materials.

Spectrum. The distribution of the components of a wave as a function of frequency. The range of components within which a signal from a particular kind of source lie; for example, audio frequency spectrum.

Telephony. The process of communicating by telephone.

Teletype. Trademark of Teletype Corporation referring to family of teleprinter equipment.

Telex. A dial-up telegraph service enabling subscribers to communicate directly with each other using teletypewriters.

Telpac. A rate structure or tariff arrangement created by AT&T in the early 1960's to provide competitive nonvoice transmission services. These rates have been the subject of continual controversy with AT&T competitors who challenge them as predatory and not reflective of real costs.

TELSTAR. Early experimental communications satellite in low earth orbit (1962-63).

Time division multiplexing. Process in which each of several modulating waveforms modulates a separate pulse subcarrier, the pulse subcarriers being spaced in time so that no pulses overlap any others. Permits simultaneous transmission of several signals over the same channel.

Transistor. An active semiconductor device with three or more terminals that is used for amplification and signal generation in electronic circuits.

Trunk. A circuit connecting two telephone exchanges in different localities. Also called a toll circuit.

TWX. Teletypewriter Exchange Service operated by AT&T whereby subscribers can communicate with each other by means of teletypewriters.

UHF. Ultra high frequency radio waves lying in the range of 300 to 3,000 MHz.

VHF. Very high frequency radio waves lying in the range of 30 to 300 MHz.

WATS. Wide Area Telephone Service provided by telephone companies that permits customers to make calls in a specific zone on a dial basis for a flat monthly charge.

Waveform. Variation in the amplitude of a signal as a function of time.

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