1.1 Social Changes

The average home has the television set on at least seven hours a day. This means that the typical high school student has spent more hours watching TV than sitting in classrooms. Consequently, the knowledge possessed by an 18-year-old American has been determined to a great extent by television. Students are likely to be much more familiar with international events than their parents were at the same age, but also less able to do routine math calculations or to write reasonably well.

The ability of the TV camera to show us what is happening in other parts of the world can greatly change our attitudes. During the Vietnam war, television brought pictures of dying men, homeless people, and starving children into our living rooms daily. No amount of flag waving or flashy parades could counter the effects of this.

In addition, television both reflects and influences the place of women in society. Seeing women depicted as lawyers, scientists, doctors, and business leaders, the public begins to accept these roles as suitable for women. Similarly, television has given the population around the country more common attitudes and experiences; it has diminished regional differences.

The adverse effects of TV are familiar. We worry that children will copy the violent behavior they see or the reckless driving habits of TV heros. The unrealistic picture of the "supermom" who holds a responsible job, runs a busy household, and continually keeps herself beautiful, energetic, and in good humor may contribute to the increase in depression among young women. Periodically there is a rash of airplane hijackings, each one receiving extensive coverage. Extremists quickly learn to use television to further their political objectives; consequently, in a sense the TV coverage of one hijacking causes another. In a similar vein, political assassinations are probably encouraged by the publicity they receive.

1.2 Political Effects

Franklin Delano Roosevelt, Adolf Hitler, and Winston Churchill were the first great masters in the use of radio to gain political objectives. All three were persuasive orators who sensed the effectiveness of this new means of mass communications. Hitler's meteoric rise to absolute power stemmed from economic and social conditions in Germany, but was possible only because of his ability to reach into every home through radio. Today, TV and radio play a central role in information control in dictatorships, and are of major importance as the Third World nations try to move toward developed status.

In our own country, we see how charismatic politicians can make use of the media.

1.3 Transportation

The worldwide air and ship transportation systems and the management of the taxi, railroad, and trucking systems, depend on rapid, accurate relaying of information by means of radar, sonar, and radio. Electronic technology makes possible the most sophisticated navigational system (Navstar) as well as the auto dashboard display that presents an ongoing record of fuel economy.

Within the next few years, communications will have a major impact on the flow of automobile traffic in urban areas. Sensors will measure traffic density and speed at many points, computers will determine optimum routes, and the system will communicate to you (the driver) how best to move toward your desired destination. You will be a part of this automated communication system.

1.4 Manufacturing

Today communication and transportation technologies mean we are living in a small world. Our manufacturing industries must compete with those of countries (such as Korea) that provide much lower wages and poorer fringe benefits. We must emphasize productivity and quality control—in other words, we must lead in automation. This essentially involves two technologies: communications and robotics.

An automobile assembly plant is one example. Here, because of options available in color and accessories, the plant makes thousands of different cars (in one year, no two cars may be identical). As the parts are assembled step by step, a central computer sends appropriate instructions to each section along the assembly line. For example, when welding is to be done, a robot must be told exactly where to weld. Furthermore, at many locations, tests are made to ensure quality; the results are communicated to the computer, which then decides on the next step. The success of such automation depends critically on the communications technology—in many cases, in an environment of excessive noise, vibration, and electromagnetic interference.

1.5 Service Industries

Communication is also central to the improved productivity and performance of the service industries (government, criminal justice, insurance, health care,

the mails, and so on). Today's banking is possible only because of electronic communications and data processing. Experts have estimated that if the methods of 1950 were still in use, the Bank of America alone would now be employing more than half of the workers in the state of California.

1.6 Entertainment

Over 100 million people watch the Super Bowl on TV. The popularity of TV news shows has unquestionably been a major factor in the sharp drop in the number of daily newspapers. Our reliance on TV, radio, and recorded music as our primary sources of entertainment affects not only our way of life, but the economy of the country as well.

These few examples illustrate how communications technology dominates our lives. I have not even mentioned such diverse applications as the use of automation in our criminal justice system, in medicine, in the military, or in helping the physically handicapped.

1.7 Factors in Decisions about a New Technology

As we consider communications systems in the following chapters, we will encounter three major factors that arise again and again in the study of technology. Besides making the work of engineers difficult and challenging, these factors must be considered by all of us when we are faced with decisions about whether to allow or encourage a new technology.

1. The technology should be matched to the characteristics and capabilities of the human users so that they will be able to use it without making major changes in their behavior. This requirement means that the engineer must be familiar with physiology and psychology. The telephone system does not attempt to reproduce all sounds made by the person speaking; that would be unnecessary and too expensive. Instead, we determine scientifically which parts of the sound are necessary in order for the message to seem natural and intelligible to the listener. For this, we need to know how human hearing works.

2. A system employing a new technology should be well-designed, because once the technology is in use changes are likely to be difficult or impossible. For example, the doctor's stethoscope—first used in the early nineteenth century—distorts chest sounds badly; nonetheless, physicians are accustomed to diagnosing from these poorly communicated sounds, and a well-engineered stethoscope with accurate reproduction of chest sounds finds no market.

3. Perhaps most important, we must anticipate the possible consequences of the new technology. While we all accept risk as a daily part of our lives, we need to weigh the risks posed by a new technology against the benefits to be derived from it.

Studying the effects of technology on human health is usually difficult, at least if we seek solid, scientific evidence. What has been the effect of radiation from citizen's band radios on truck drivers and motorists? Unfortunately, even major epidemiological studies may be unable to answer such a question, since environmental effects often appear only decades later, and since the causes may be synergistic (for example, drivers who use CB radios may have other habits whose effects combine with the radiation and make it hazardous).

The risks of a new technology may be economic or social as well as medical. For example, more and more states are authorizing "home arrests." The convicted criminal is allowed to live at home, but must wear an ankle bracelet containing a radio transmitter to allow continuous monitoring of his location. Such a system clearly reduces the crowding of our prisons, but it raises the specter of invasion of privacy.

A new technology is often watched closely only until it becomes commonplace; then the monitoring is relaxed or disappears.

1.8 Measuring Information—A Central Concept

As we consider the various aspects of communications technology, we will find one concept appearing again and again—a concept which is the heart of engineering. A technology is designed on the basis of measurement of the information that is to be transmitted. In other words, how complex is the signal? If one computer is "talking" to another, relatively simple messages are sent and received—perhaps just a long sequence of zeros and ones. The information sent to create a changing television picture is much more complicated; for each point in the picture, both the brightness and the color must be communicated.

The idea of measuring information is crucial when a new technology interacts with people. When you receive new information (for example, by sight), you first store this information in your brain's short-term memory. If you will want to remember this much later, you then transfer it to your long-term memory. Suppose you look up a telephone number in the directory, then walk across the room to the phone. Unfortunately, by the time you start dialing, you have forgotten the number. The trouble is that you have not transferred the number to your long-term memory, and your short-term memory is able to store only about four chunks of information.

1.9 The Plan of the Book

The main topics of this book are the scientific principles that underlie the design of modern communications systems, the capabilities of these systems, their danger, and their impact on our lives. We are interested in electronic communication from person to person (both between two people and from one to many); from person to machine, and vice versa; and from machine to machine, as between computers.

Our interest is restricted to messages and information we can measure. When two people carry on a face-to-face conversation, probably more than half the information is conveyed by facial expressions and body language—aspects we still cannot measure well and hence cannot enhance or reproduce with technology. While we struggle to produce satisfactory computer-generated speech, we do not worry about giving the computer a capability for body language.

The underlying goal of the book is to show that modern technology is understandable by the layperson. I want to break down the barrier that separates the scientist-engineer from other concerned citizens. I want to convince you to become at least reasonably knowledgeable about technology, which so dominates our environment, so that you can assume a full role in today's world.