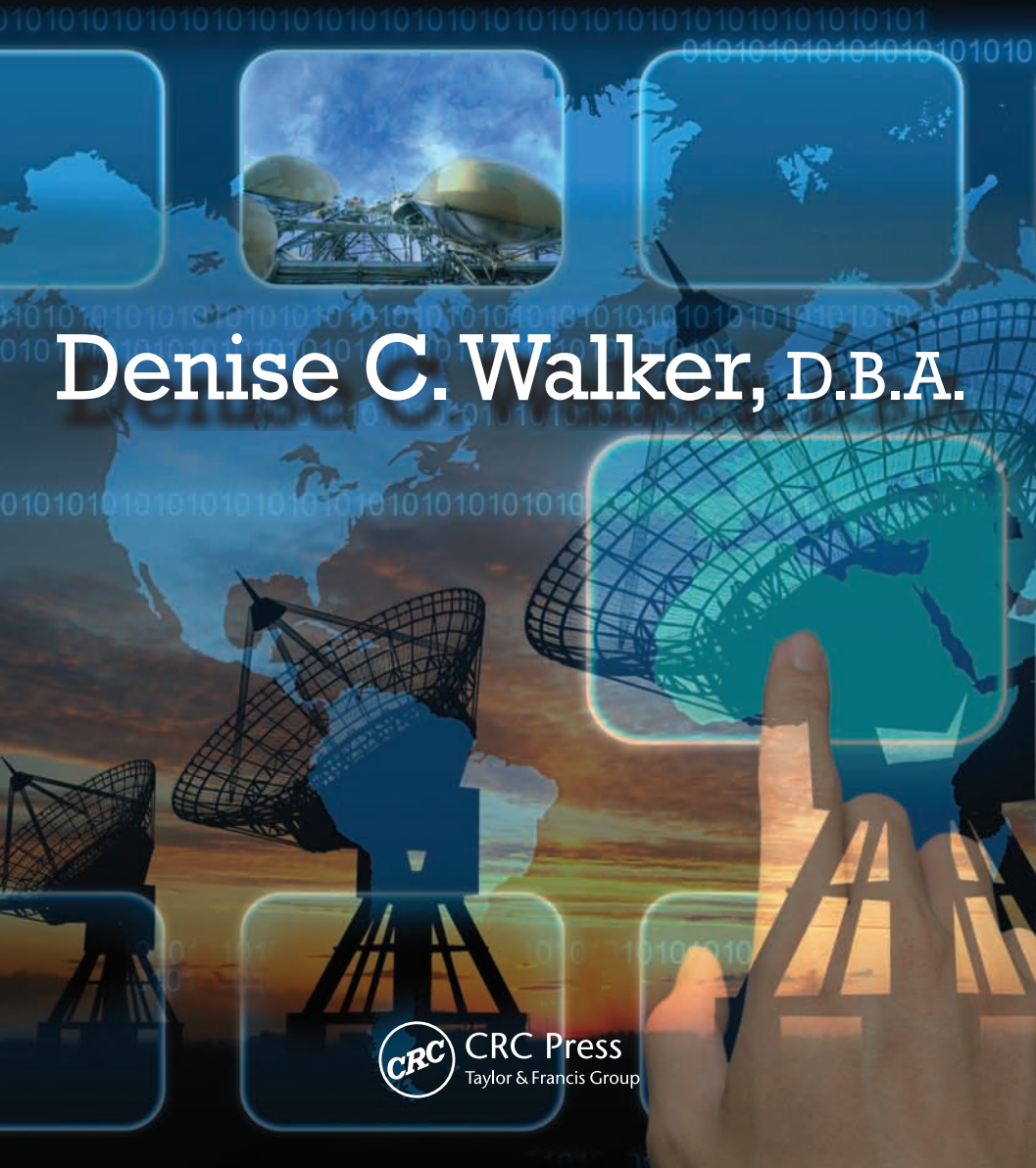
Mass Notification and Crisis Communications

Planning, Preparedness, and Systems



Denise C. Walker, D.B.A.

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This book is dedicated to you.

This book is also dedicated to my husband Alfred,
my children Charles, Anthony, Crystal, and Marvin, and
my father Samuel Chatam
whose steadfast love and support made this book possible.

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Preface

As I finished this manuscript, I was reminded about what had inspired me to share what I know about crisis communications and mass notification. I came across a massive amount of information, from many diverse sources, and as expensive "must have" solutions. Too many organizations I spoke with said they simply could neither afford the "must haves" nor hire a consultant to mine though the web of data to find the best fitting solution. This was an interesting thought. I spent many months hiding away like a hermit and overcoming challenges in writing this book to address this issue. My aim was to offer a trusted resource to guide you through the mountains of data on mass notification and crisis communications planning, preparedness, and systems. My writing is based on sound research, real-world case studies, and my own experiences.

This book is more than the ABCs of creating an on-point crisis communiqué in the midst of a storm. It is about reaching the masses in a targeted and timely manner using what you have and buying what you can afford. Information included is a review of challenges organizations face with communications and the types of disasters predicted in the future. The information here assists in defining your target audiences—your stakeholders—those with every means of communication available to them and those with none. It describes different communication techniques used throughout history during peace and wartime, and provides methods on consistently getting your message right the first time.

This book helps you to create a crisis communications plan that works and analyzes the technology used for crisis communications and mass notification. The material provides a comprehensive appraisal of the technology you already have and other solutions available—from e-mail and social media to sonic buoys and early earthquake warning systems. This book goes a step further; it looks at the legal landscape, the processes for product selection, identifying requirements, designing your integrated solution, testing your program, and maintaining systems. This book offers a broadminded view of key decision-making considerations, the financial and mental health aspects of crisis communications, marketing and message mapping, and pathways for building

new relationships. The approach used throughout the book aligns with the U.S. Department of Homeland Security National Emergency Communications Plan, the U.S. strategic plan to improve emergency response communications, and public expectations.

Learning is a passion of mine; sharing what I have learned is my way of giving back. It is with this spirit, I share the experiences I have learned in an organized and straightforward way about crisis communications and mass notification. I thank my husband, children, and parents for their support. I thank you for the privilege of sharing this information with you.

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CHAPTER 1

History of Communications

The single biggest problem in communication
is the illusion that it has taken place.

George Bernard Shaw

HISTORY OF COMMUNICATIONS

The history of communications began with the start of life, and it has been a part of our lives ever since. *Communication* means information that is shared by two or more people. Communications includes a sender and a receiver. The *sender* is the one that triggers the message. The *receiver* is the party who receives the message.

For communications to occur between a sender and receiver, you first need media to send the message (the output) from the sender. *Media* is the resource used for send a message, such as paper, television, telephone, or smoke signals. Once the sender has selected a media, the sender will transmit the message. *Transmission* is the method used for sending a message, such as over the radio or cellular phones, by airwaves, or using a physical transporter such as a homing pigeon or postal service. The media and transmission used by the sender will determine how well the message is received, called *reception*. Is the radio transmission clear enough to be intelligible or is the handwriting legible? As the message is received, it is interpreted by the receiver and becomes the input. Interpretation by the receiver is the most critical component in the formation of a common understanding between the sender and the receiver. *Interpretation* determines how well the receiver understands what has been sent (see Figure 1.1 Communications process).

Does the sender write the message in English not knowing whether the receiver can read, write, speak, or understand English? Must the receiver hear the message in order to interpret its meaning even though the sender is unsure whether the receiver is hearing-impaired or otherwise

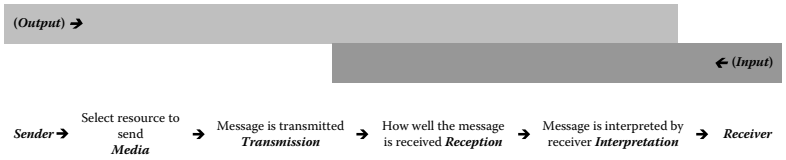

FIGURE 1.1 Communications process.

unable to interpret the message? To have a common understanding between the sender and receiver the media, transmission, reception, and interpretation considerations play a pivotal role in communications.

COMMUNICATIONS—3500 BC TO 1 BC

There are records dating back to 3500 BC showing a time when paintings were made by indigenous tribes as a means to communicate. Around that period, the Sumerians developed *pictographs* of events that were written on clay tablets. The Egyptians also created *hieroglyphic writing* (see Figure 1.2 Early Egyptian hieroglyphic alphabet). In 1500 BC, the Phoenicians created an alphabet. In 1400 BC, bones were used for writing in China, the oldest record of writing. In 1300 BC, drum beat codes sounded alarms during the Shang Dynasty in China. The Chinese government introduced the first *postal service* in 900 BC. The postal service was one of the first processes used to deliver communications over a distance to a specific individual.

In 776 BC, homing pigeons were used to send messages including an announcement of the winner of the Olympic Games to the Athenians. Before homing pigeons, human messengers running on foot or horseback were the only way to send messages from town to town or to relay orders and

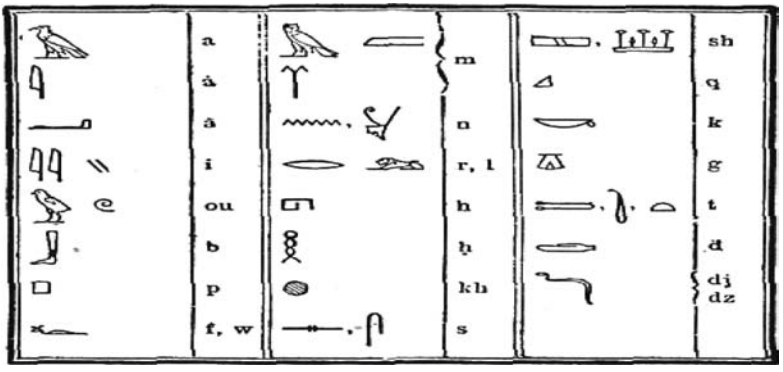

FIGURE 1.2 Early Egyptian hieroglyphic alphabet.

intelligence during wartime. This was a dangerous task for human messengers. Messengers were killed, bribed, or their messages intercepted. About 400 years later, more effective communication methods were introduced.

Between 1200 BC and 100 BC, fire messages were used from relay station to station instead of human messengers in Egypt and China. In ancient Greece, the Greek were reported to have used fire signals to send a message from Troy to the city of Argos (chief town in eastern Peloponnese), about 325 miles (600 km) in the late eleventh century BC. Troy was located on the top of the Hisarlik, a mountain in western Anatolia, the area now known as Turkey. It was said that alone on the Argos palace roof, the watchman awaited the fire signal that would tell the household that the Greeks had captured Troy. The message reached the city of Argos after a few hours.[1] Smoke signals were also used by Native American tribes.

HELIOGRAPHS

Sending messages using mirrors or shiny metals and the rays from the sun has been done by flashing reflected rays to another location up to 50 miles away. This form of communicating is known as *heliography,* with the first recorded use in 405 BC. The ancient Greeks used their polished shields to signal in battle. The Roman emperor Tiberius was thought to have sent coded orders using heliographs daily to the mainland, about 8 miles (12.8 km) away in 37 AD. The Egyptians were also known to have use heliographs that could be seen as far as 80 miles away.[2]

Thousands of years later, heliographs remain in use. As late as 1979, Afghan forces were reported to use heliographs to warn of approaching enemy troops during the Soviet invasion of Afghanistan. Today, heliographs are included in some survival kits used by hikers and pilots for *emergency* signaling and for the search and rescue of aircraft. An *emergency* is a situation or event that presents an immediate risk to life, health, property, or the environment. Heliographs are also used to measure long distances by triangulations by the U.S. Coast Guard and for geological surveys in the early 1900s.[3]

Other primitive forms of communications used for telegraphy over distances include smoke signals, torch signaling, and signal flags. The word *telegraph,* with its origins from the union of Greek words *tele* and *graph,* that essentially mean "long-distance writing."

PAPER, NEWSPAPERS, AND MAGAZINES

The Chinese were the first to use paper in 104 AD. In 1450, when paper was easily produced and widely available, newspapers were created in

Europe. In Renaissance Europe, newsletters were handwritten and privately circulated among merchants. They disclosed information about wars, economic conditions, social customs and "human interest" features. Printed news pamphlets, also known as *broadsides,* were the forerunners of the newspaper. German broadsides of the late 1400s had highly sensationalized content.

Newspaper circulations have grown over the years. The United States had nearly 2,150 daily newspapers in circulation in 1900 and peaked at 2,200 by 1910. Daily newspapers were a way to share information on events in the coverage area and world news. By 1967, most newspaper and magazine production was digitized (Media History Project). In 1910, there were an estimated 1,800 magazines in publications. A *magazine* is a publication published periodically, less frequently than newspapers.

TELEGRAPH SERVICE AND MORSE CODE

Telegraph Service

A Frenchman named Claude Chappe invented the first long-distance semaphone telegraph line in 1793. Telegraph services was used during the Revolutionary and Napoleonic wars when communication systems were simplistic, relying mainly on mounted dispatch riders. As telegraph service was adopted, communication towers were erected in the line of sight of each other. Once the towers were installed, the French sent a signal using the telegraph system from Paris to Lille, approximately 118 miles (191 km) in five minutes. Each tower had 196 combinations, also known as *signs*, and each was worked by a series of pulleys and levers. An operator could send three signs in a minute, provided visibility was good.

There were a number of significant communication "firsts" during the eighteenth century. Many of these can be attributed to the military needs of the time. Major wars include the French Revolution starting in 1789, the Napoleonic Wars that began in 1803, the Mexican–American War of 1846, and the U.S. Civil War in 1861. The first optical telegraph system was invented in the mid-1800s that covered approximately 3,100 miles (5,000 km) and encompassed more than 550 stations. These early systems included the naval semaphore system, the railroad semaphore system, and the "wig-wag" system.

William Cooke and Charles Wheatstone developed an early form of telegraphy system called the English Needle Telegraph in 1837. This system used pointing needles rotating over an alphabetical chart to indicate the letters that had been sent. The major drawbacks of this system were

that it had a complex configuration and it was slow. These were common issues among electrical telegraphing systems of this era.

Optical and visual telegraphy systems enabled information to be transmitted more quickly than the fastest form of transportation. This is at a time when advances in communications had outpaced earlier messenger systems. Telegraphy systems enabled the use of error control (resending lost characters), message priority, and the flow control (send faster or slower) for the first time. These were significant milestones in communications. These concepts remain in use today for crisis and emergency communications. Telegraphy systems continued to evolve with encoded shutter system developments in Sweden and England in the late 1800s.

Morse Code

Samuel Finley Breese Morse invented the *Morse code* in 1835, a landmark in using technology to communicate electronically. Morse code is a method for transmitting textual information using a series of indentation marks (dots and dashes) on paper tape that can be directly understood by a skilled listener or observer without special equipment (see Figure 1.3 Morse code).[4] The system sent pulses of electric current along wires that were controlled by the receiving end of the telegraph system to deflect an electromagnet.

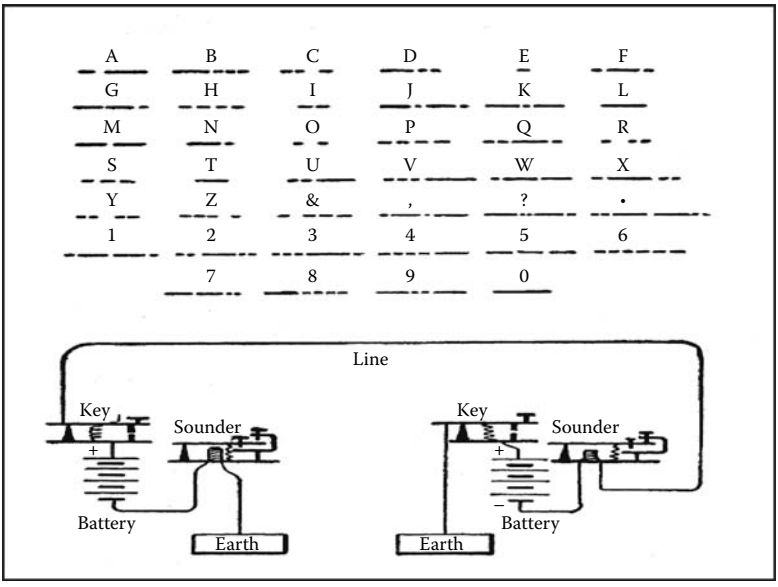

FIGURE 1.3 Morse code.

Samuel Morse entered into an agreement with Alfred Vail to expand the original code to include the alphabet, numbers, and special characters for broader appeal. A group of "dots" also known as *dit* (·) or short marks and "dashes," also known as *dah (-)* or longer marks are assigned to a character. Pauses, referred to as *gaps,* are used between letters, words, and sentences. A short gap is used between letters, a medium gap is used between words, and a long gap is used between sentences.

Eight years later, in 1843, Samuel Morse invented the first long-distance electric telegraph line. The first telegraph message was sent electrically from the U.S. Supreme Court chamber in Washington, DC, to the railway depot in Baltimore, Maryland. Congress funded construction of this experimental telegraph line. The U.S. Morse code was sometimes known as the "Railroad Morse." A trained operator could now send or receive 40–50 words per minute. By 1914, automated transmission was in use. A trained operator could handle more than twice the original rate.

The modern International Morse code invented by Friedrich Gerke was introduced in 1848. Morse code gained popularity in Europe while the United States continued to use the former version. The International Morse code eliminated the use of spaced dots. This system had an advantage over other forms of communications during this time because it had an easy working principle, and it could function efficiently with low-quality wires common in rural areas. As the number of users and undersea cables increased, transmission errors occurred.

Morse code with its many improvements became a mainstay in communications during disasters and emergencies for more than 160 years. A *disaster* is a natural situation or event that overwhelms the local capacity to respond, recover, prevent, or mitigate damage and may require a request for external help. Morse code was the backbone of early emergency communications technology.

MAIL AND PARCELS

The Chinese introduced the first *postal service* in 900 BC. The Pony Express was used for U.S. mail delivery during the Wild West days; by 1912, the first mail was carried by airplane.

Toronto, Canada, first used numbered postal zones in 1925. By the 1940s other Canadian cities were using the system. For example, the postal zone used for Toronto was 5. Mail would be addressed giving the postal zone name and postal zone number, and province, that is, Toronto 5, Ontario. By 1943, the City of Toronto was divided into 14 zones using the numbers 1 through 6, 8 through 10, and 12 through 15. The numbers 7 and 11 were not used and a 2B zone was added.

Today the postal code contains six alphanumeric characters in the form of A#A #A#. The letter "A" represents an alphabetic character and the # represents a numeric character. The postal code consists of two three-character segments. The first section is for the forward sortation area A#A, and the second section is for the local delivery unit #A#. Similar systems were implemented elsewhere around the world over the next 20 years.[5]

In 1943, the U.S. Postal Service (USPS) started using postal zones for large U.S. metropolitan areas. In 1963, 20 years later, the USPS introduced *ZIP codes* to leverage technology in managing the explosive growth of mail. ZIP is the acronym for *Zoning Improvement Plan*. The use of ZIP codes was optional until 1967 when USPS required all second-class and third-class mail to be presorted by ZIP code. In 1983, the ZIP+4 system, also called the "plus-four codes" or "add-on codes," was implemented by USPS. The additional four digits represent a geographic area within a ZIP code delivery area, such as an apartment complex, neighborhood, or other small community. A postal bar code is now used for automated sorting of mail called the *Postnet*. There are long Postnet bar that contain the ZIP+4 code and the short-Postnet bar that contains only the five-digit ZIP code.

In addition to ZIP codes, globally ISO2 and ISO3 codes are now used to define a country such as the US (ISO2) and USA (ISO3) country codes. ISO represents the *International Organization for Standardization*. ISO 3166 standard provides a listing of two and three character codes that represent countries, dependent territories, and unique areas of geographical interest.[6]

FACSIMILE (FAX)

Alexander Bain of England patented the first facsimile (fax) machine in 1843. Bain's fax machine consisted of two pens attached to pendulums that were connected by a telegraph wire. When an electrical charge was sent through the telegraph wire, the pendulums would pass over chemically treated paper and would make stains as directed. Five years later, Frederick Bakewell invented a conducting roller. The transmission began as revolving drums covered with treated tinfoil turned and on the receiving end, the receiver would receive a recorded image. The first transatlantic fax service was provided by the company RCA in 1922.

Fax services were used primarily by newspapers to transmit photographs, the weather service to fax weather charts, and later by the military to transmit maps, orders and weather charts. In 1960, USPS experimented with facsimile mail. Xerox, in 1966, emerged and sold the first successful *telecopier* in the United States, a fax machine called

the Telecopier I (Magnafax).[7] Telecopier, also called fax machine, is the equipment used for transmitting a copy of a document to the receiving fax machine. Fax machines remain in use, with facsimile servicers delivering facsimiles via the Internet and IP fax services. Today, the Internet's global electronic communications system connects computer networks and organizational computer facilities, providing public and private access to information to its users.

By 1983, the popularity of faxing grew exponentially. The Comité Consultatif International Téléphonique et Télégraphique (or CCITT Group 3) increased the standard protocol to 9,600 bits per second (bps). The CCITT was an organization that set international communications standards. Fax machines are commonly use at work and home. Faxes are widely accepted as legal documents, particularly since it can capture from where, when, and who sent the fax. A fax can also include handwritten information such as a signature.

In the 1800s, advancements in communications technology were occurring in many different areas. Coleman Sellers invented a machine that flashed a series of still photographs onto a screen, called a *kinematoscope*, in 1861. Early motion picture cameras and projectors that could photograph motion pictures were called *kinetograph*.[8] Kinetographs were later followed by the kinematoscope in 1890. Thomas Edison and his assistant William Dickson were credited with the development of the kinetograph.

The kinetograph, a motor-driven camera, could capture movement with a synchronized shutter and sprocket system. This system would move film through the camera using an electric motor. The film, made by Eastman and according to Edison's specifications, was 35 mm wide and had sprocket holes on the sides to advance the film. Edison's Kinetograph camera essentially has became the standard for theatrical motion picture cameras used today.

The United States' involvement in World War II led to a proliferation of patriotism and propaganda movies. Two U.S. films, *The Desperate Journey* (1942) and *Forever and a Day* (1943) were movies of patriotism and propaganda. The need for wartime propaganda also occurred in Britain with war dramas such as *The Forty-Ninth Parallel* (1941) and *Went the Day Well?* (1942).

TELEPHONE

In 1875, Alexander Graham Bell developed "harmonic telegraphy" with which he could hear a sound over a wire. In 1876, Bell patented the electric *telephone*, devices that can transmit speech electrically. Elisha Gray also invented a different electric telephone. Both men rushed to the patent office with Bell patenting his telephone first, just hours before Gray.

A famous legal battle ensued between the two men over the invention of the telephone with Bell emerging the winner.

By 1905, approximately 2.2 million telephones were active within the Bell System. The first coast-to-coast telephone line, from New York to San Francisco was completed by the Bell System in 1915. Combining "harmonic telegraphy" and traditional Morse code telegraphy led to a new generation of communication devices that could be used in times of peace and for disaster communications.

Shortly thereafter, overseas cable installations began to connect the United States to other countries. In 1918, a major business disruption occurred when the U.S. government took over the telephone service. After the attack on Pearl Harbor during WWII, the volume of calls increased dramatically and telephone technicians were called into service by the thousands. Western Electric shifted 85% of its output to war-related projects leaving home phone service as a low priority, and many users without regular service. By 1956, the first transatlantic cable between England and Newfoundland opened.

MOBILE PHONE

Lars Magnus Ericsson developed the first mobile telephone application in the early twentieth century. Today, Ericsson is a global provider of telecommunications equipment and related services to mobile and fixed network operators. This was a portable phone handset with a crank that could be hooked to bare phone wires. The connection was made using a pair of metal hooks that were placed over the wires using an extension wand. Once contact with the wires was made, the magneto in the handbox was cranked. This would make a signal that could be answered by someone on the line. Around 1907 this system was used to report a train robbery that led to the arrest of the bandits. In 1946 the first commercial mobile phones were installed in St. Louis.

Telephone service has served as the basic communication link. Phone services can be completed using cellular phones, satellite phones, and computers that have each revolutionized personal and commercial communications. Telephone service has served as the basic communication link worldwide since its inception and remains a true statement today and for the near future.

COPY MACHINE

Thomas Edison patented the office copying machine called a *mimeograph* in 1876. A mimeograph machine, also called "mimeo," is a

printing press that forces ink through a stencil onto paper. Early versions had an electric pen that was used for making a stencil and a flatbed duplicating press. It was used to print short-run classroom materials, classroom and local bulletins, and office work. Many developing countries continue to use this device. In developed countries, this machine has been replaced by less expensive photocopying and offset printing that was developed in the 1960s.

LOUDSPEAKERS

In 1877, Ernst Siemens of Germany patented the first *loudspeaker.* Loudspeakers were later redesigned to use electricity. By 1916, the electric loudspeaker was introduced. In 1924 Chester Rice and Edward Kellogg, two GE researchers, patented the modern loudspeaker that contained a moving coil-driven mass-controlled diaphragm in a baffle and direct radiator. This design remains in use today.

The quality of loudspeaker systems has made significant audible improvements over the last 50 years. These improvements are due to continuous developments in enclosure design and materials using computer-aided design and finite element analysis. Loudspeakers are used to give updates at sporting events and to provide warnings of impending danger. Loudspeakers can offer both a voice and a tone.

MAGNETIC RECORDING

Valdemar Poulsen invented the first magnetic recordings using magnetized steel tape for the recording medium. The use of magnetic recording was the start in using disk and tape for mass data storage. The music recording industry and radio used tape as early as the 1930s, and tape continued for years to come. In 1963, Phillips developed the compact cassette with Dolby noise reduction technology. Cassettes markedly improved the quality of recorded sound. In 1979, Sony developed the Walkman, which used compact cassettes.

These developments led to the widespread use of magnetic audio tape. Revolutionary changes for radio and the recording industry occurred now that sound could be recorded, erased, and rerecorded using the same tape multiple times. These tapes also got smaller. Preproduced programming on tape cartridges could have endless loops. This helped the broadcasting industry and led to growth in the monitoring of the industry. Hitachi and New Energy and Industrial Technology Development Organization (NEDO),[18] have developed technologies for microwave magnetic recording that will expand the recording density

of *hard disk drives* (HDD) to greater than 1.5 TB for even rugged mini external HDD.

RADIO

At the start of the twentieth century, more advancement occurred in the use of technology to communicate to larger audiences over longer distances. The *radio* came into use with its modulation of electromagnetic waves to transmit signals with frequencies below those of visible light.

An Italian inventor named Guglielmo Marconi in 1894 built his first radio equipment, which could ring a bell from 30 feet away—the first radio signal. In 1899, he sent a wireless signal across the English Channel.[9] In 1901 Marconi had his staff in Poldhu, Cornwall, England, transmit the Morse code letter "s" (three dots) at an appointed time. The letter "s" was chosen since it was easy to distinguish. Marconi pressed his ear to the telephone headset attached to his receiver and successfully heard "pip, pip, pip" 1,700 miles away from the transmitter—across the Atlantic from Cornwall to Newfoundland. Marconi's telegraphy sparked gap technology within a broad segment of the *radio spectrum*. The radio spectrum is the radio frequency (RF) portion of the electromagnetic spectrum.[10] This transoceanic signaling became a part of his business empire of ship-to-ship and ship-to-shore communications, including the communication system used on the *Titanic*.[11]

The sinking of the *Titanic* led to a U.S. Senate investigation into the practices of Marconi's business. It was found that there were several ships that were responding to the *Titanic* distress signals. The ship that was closer did not receive signals from the *Titanic* since the vessel's only radio operator was off duty. The investigation concluded that with the earlier arrival of the closer ship more lives could have been saved.

The U.S. Radio Act of 1912 was enacted, which required that at least two radio operators are on board all vessels with more than 50 passengers and at least one operator had to be on duty in the Marconi room at all times the vessel was at sea. This was landmark legislation in a largely unregulated industry, where unfettered development and use of communications led to the early control of communications and the formation of some important principles in the use of communications technology.

Marconi was only one individual who influenced the early years of radio. Others include Nikola Tesla, Alexander Popov, Sir Oliver Lodge, Reginald Fessenden, and Heinrich Hertz among others listed below. The key accomplishments by year, the name of the inventor, and the invention or notable works are mentioned in Table 1.1 (Radio Inventors and Their Notable Works) for the early years of radio.

TABLE 1.1 Radio Inventors and Their Notable Works

Year	Name	Inventions/Notable Works
1864	James Clerk Maxwell	• A Scottish physicist and mathematician. • Maxwell predicted the existence of radio waves. It was on this basis that radio waves were discovered and Einstein's theory of relativity gained traction.
1868	Mahlon Loomis	• A Washington, DC, dentist. • The first wireless telegrapher to demonstrate a wireless communication system that could operate between two sites. The sites were 14 to 18 miles apart.
1882	Amos Dolbear	• An American physicist, inventor, and Tufts University professor. • Received a U.S. patent for a wireless telegraph.
1888	Heinrich Hertz	• A German physicist. • The first individual to validate the presence of electromagnetic waves by constructing a system to create and detect UHF radio waves in 1888. • Hertz's name is used to represent radio frequencies and was officially added to the metric system in 1933.
1892	Nikola Tesla	• An inventor, mechanical engineer, and electrical engineer. • Tesla is the designer of the early radio in 1892. • Tesla patented a radio-controlled robot boat that was directed by radio waves in 1898.
1894	Alexander Popov	• A Russian physicist. • Popov constructed the first radio receiver containing a "coherer" in 1894. A coherer is a primitive form of radio signal detector used in the first radio receivers. • Popov's radio was modified to a lightning detector that was demonstrated before the Russian Physical and Chemical Society in 1895. • He sent the transmission of radio waves across different campus buildings at St. Petersburg in 1896.
1894	Sir Oliver Lodge	• A British physicist and writer. • Lodge perfected the design of the coherer. His was a radio-wave detector and the basis of the early radiotelegraph receiver. • He is considered the first to transmit a radio signal.

TABLE 1.1 (continued) Radio Inventors and Their Notable Works

Year	Name	Inventions/Notable Works
1895	Guglielmo Marconi	• An Italian inventor. • Marconi conducted the first experimental transmission of wireless signals. • He filed a U.S. patent for wireless communication in 1896. • Marconi demonstrated the first transatlantic wireless transmission between Poldhu, England, and St. John's, Newfoundland, by using Morse code in 1901.
1898	Nathan Stubblefield	• An American inventor and Kentucky melon farmer. • Thought to have actually invented the radio before Tesla and Marconi. • Stubblefield's device worked by audio frequency induction or audio frequency earth conduction rather than radio frequency radiation for radio transmission telecommunication. • There are also reports that Stubblefield is the inventor of wireless telephony or wireless transmission of the human voice.
1900	Reginald Fessenden	• A Canadian inventor. • Fessenden sent the first audio transmission by radio in 1900. • He sent the first two-way transatlantic radio transmission in 1906. • He designed a high-frequency alternator and transmitted human voice over the radio in 1906. • He went on the airways with the first radio broadcast of entertainment and music in 1906. • He stated that he had a better spark-gap transmitter and coherer-receiver combination than those developed by Lodge and Marconi.
1903	Valdemar Poulsen	• A Danish engineer. • Poulsen began arc transmission to create high-frequency alternators for sending radio waves. The *New York Times* and the *Times* of London knew about the Russo-Japanese War due to radio transmissions in 1903.
1906	Lee de Forest	• An inventor with more than 180 U.S. patents. • De Forest made the detection, transmission, and amplification of sound possible.

The term *radio* was adopted by the U.S. Navy in 1912 and was commonly used by the public when the first U.S. commercial broadcasts occurred in the 1920s. Between 1911 and 1930, the growth in radio exploded in the United States and across the Atlantic Ocean. The Radio Corporation of America was formed by combining General Electric (GE), Western Electric, AT&T, and Westinghouse. In France, battery-powered receivers with headphones and valves were seen. Radio broadcasting began in Asia and the Caribbean—in Shanghai and Cuba—and the first regular broadcasts occurred in Australia, Belgium, Finland, Germany, Norway, and Switzerland. By the 1930s, radio was prevalent around the world.

Telephone and radio communications were enhanced with the use of the electronic amplifying tube also known as the *triode*, which enabled all electronic signals to be amplified. Lee de Forest introduced the triode in 1906. In less than eight years after the introduction of the triode, the first cross-continental telephone call was made in 1914. *Radio telephony*, also known as voice communications using radio waves, was developed to support safety and military communications.

Early radio supported maritime vessels and was used for sending telegraphic messages using Morse code between ships and land. The Japanese Navy scouting the Russian fleet during the Battle of Tsushima in 1905 was one of the early adopters of radio. Radio was used to pass on orders and communications between armies and navies on both sides in World War I. Germany used radio communications for diplomatic messages once it discovered that the British had tapped its submarine communications cables. The United States passed on President Woodrow Wilson's Fourteen Points to Germany via radio during the war.

Amateur Radio

The countries that were using radio and had the technology were also adopting the concept of amateur radio. Much of the implementation of amateur radio was completed using a combination of scientists, hobbyists, and others familiar with Marconi's radio communications systems. As use of the radio spectrum grew in the first quarter of the twentieth century, a portion of the spectrum was allocated for amateur use. The need for systematic relay of messages became evident as the portion of the radio spectrum allotted for amateur use could carry messages only over relatively short distances. Shortly after a portion of the radio spectrum was allocated for amateur use the United States entered in to World War I. The U.S. Navy seized controls of radio and shut down the amateur radio transmitters in 1917. Within a year, the amateur radio transmitters were restored for use.

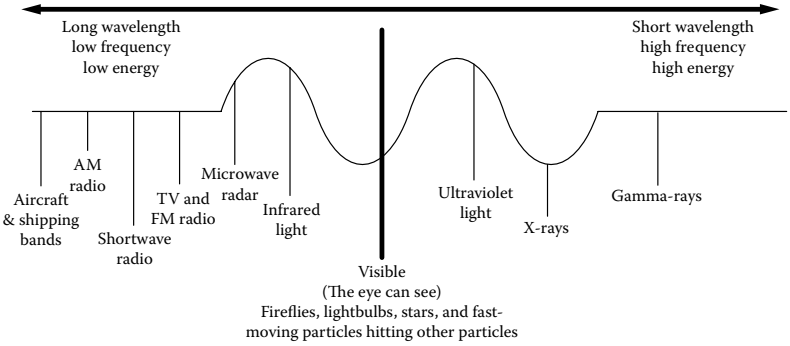

FIGURE 1.4 Electromagnetic spectrum.

In 1919, *shortwave radio*, referring to the high frequency (HF) portion of the radio spectrum was discovered. Shortwave radio is used by amateur radio, for broadcasting voice and music, and used for long-distance communication in remote areas, aircraft in flight, ships at sea, and other areas where wired communication or other radio services may be out of reach. (See Figure 1.4 Electromagnetic spectrum.)

Hiram Percy Maxim, in 1919, originated the American Radio Relay League (ARRL). The ARRL was a voluntary network of associated radio amateurs whose purpose was to facilitate the long-range relay of *radiograms*. Radiograms are written messages, telegram style messages, routed through a network of amateur radio operators who are on the air to relay messages over the radio. Similar associations were established outside the United States to foster long-distance passage of radiograms.

As ARRL and the use of radiograms grew, the reliability and accuracy in relaying these messages increased in importance. Radiograms were adopted for military, commercial, and public service relay of information concurrently. Standardized message formats were established. Military and commercial services were staffed by amateur radio operations.

As processes evolved, the National Traffic System was created and in conjunction with the ARRL, radio messages were passed nationwide for commercial, health and welfare, and disaster information in this manner. The National Traffic System format for messages or radiograms, including voice messages, remains active today. A movement to redesign the format so that it can easily interface with the technologies and techniques used today to transmit and receive disaster communications are under way under the IPAWS system.

The ARRL developed an Emergency Corps in 1940 before the U.S. involvement in World War II. The Emergency Corps trained and drilled even on frequencies that were closed for casual amateur use. Hundreds of these amateur operators would staff listening and direction finding

stations. ARRL became the War Emergency Radio Service in 1942 where its primary purpose was air raid protection and notification. In 1948, the Military Affiliate Radio System was established.

The Military Affiliate Radio System was an integration of amateur operators, also known as *hams*, and military operators using a common set of frequencies worldwide. Hams are radio hobbyists licensed to transmit radio signals as a leisure-time interest, and if desired for emergency and public service communications. Hams are licensed to use frequencies in a wide range of *narrowbands* throughout the radio spectrum. To become a member of the Military Affiliate Radio System, an operator is required to receive a base level of training and continuing active participation in practice nets and drills are required. This requirement continues today.

Narrowband refer to the bandwidth of a radio message not exceeding its channel's maximum bandwidth. Narrowband communications provides stable long-range communication where the carrier purity of transmission spectrum is good, and able to manage an operation of many radio devices within same frequency bandwidth simultaneously. Narrowband is ideal for areas where many radio-control devices are used such as at a construction site.

Around 1952, the Radio Amateur Civil Emergency Services (RACES) was formed in concurrence with the federal Civil Defense effort. This was just as the Cold War began. Organizations like RACES were established around the world over the next 25 years. Federal and local authorities realized the need for disaster and emergency communications that went beyond military and nuclear disasters but comprised all facets of civil life. In 1972, the U.S. Civil Defense name was changed to the Federal Emergency Management Agency (FEMA).

FEMA and the FCC, in accordance with FCC Part 97, Section 407, govern all U.S. RACES organizations today. All transmitted communications in RACES must be authorized by the civil defense organization for the area served. The only types of messages that may be sent are concerning:

1. Impending or actual conditions jeopardizing public safety during civil emergencies
2. Immediate safety of life, protection of property, maintenance of law and order, alleviating human suffering and need, and combating an attack
3. Public information essential to activities of civil defense or other government or relief agencies
4. Communications for RACES training, testing and drills.[12]

By the 1970s, transistors and integrated circuits were in existence. Ham radio operators were using this technology to develop new ways to use the most advanced communications technologies on a range of frequencies from the lowest to microwaves. As technology evolved so did emergency preparedness activities.

AM Broadcasting

AM broadcasting uses amplitude modulation for radio broadcasting. An AM receiver is used to detect amplitude variations in radio waves at a specific frequency. Using the specified frequency the receiver amplifies changes in the signal voltage to push sound through a loudspeaker or earphones. An example of AM broadcasting is if an AM radio station is broadcasting at 440 Hz sound, the signal gets louder and quieter 440 times every second. The signal adjusts in Hertz's, as the frequency is increased or decreased. This results in the listener hearing the encoded information rather than the actual radio signal.

AM radio broadcasting was the primary method for broadcasting for the first 75 years of the 1900s and used today. Reginal Fessenden, a Canadian, launched the first experimental AM radio broadcast in 1906 on Christmas Eve. In 1909, Charles "Doc" Herrold began weekly broadcasts in San Jose, California, on radio station KCBS. KCBS claims to be the world's oldest broadcasting station, having celebrated its 100th anniversary in 2009.

Radio programming mushroomed between the 1920s and 1950s, following World War I, an era known as the "Golden Age of Radio." Comedies, dramas, soap operas, and music were developed and broadcasted. In Britain and the United States, the institutionalization of radio began in 1927. In America, establishment of the Federal Radio Commission ended chaotic noise and harshness in the sound of words or phrases on the airwaves.

The 1930s was a time of widespread want and deprivation due to the Great Depression, and it is a time that is marked as an important stage in the evolution of a mass consumer society in the United States. Many in this country dealt with economic hardship. Simultaneously, the U.S. appetite for a variety of consumer goods grew, thanks to media, specifically radio. Radio moved the culture towards a national consumer culture. The "American way of life" and the "American Dream" took root during this era. The early radio soap opera were daytime serials that appealed to American homemakers who were most likely to purchase many of the household products.[13]

At the start of the 1940s, radio was used as a primary medium to prepare people for the possibility that the war in Europe could soon command American participation, fueling anxieties about national cohesiveness. This was exacerbated during a decade of economic depression. Although the national networks dominated the radio airwaves at the beginning of the 1940s, by the end of the decade, some of that power shifted as changes occurred in the industry. National demographics allowed for the emergence of stronger independent urban radio stations and more politically daring broadcasts.

AM radio stations use ranges from 250 to 50,000 watts. Experimental licenses were issued before World War II for 500,000 watts. These stations were established for wide-area communications during disasters. These stations were decommissioned in the early 1940s in the United States and Canada. In Mexico, a few stations operated at 250,000 watts, and other countries authorize high power operations.

Radio was distinguished as the desired medium for mass communication since radio programs came directly into the home. This gave radio a convenience and an intimacy that no other communication agency had at this time. The 1950s began with President Truman delivering a message on the U.S. position of strengthening the defense of Europe and the nature of Germany's contribution to the war.

AM radio remains vulnerable to atmospheric disturbances such as lightning strikes, static electricity, and other sources that can cause brief spikes or troughs to the signal. These disturbances cause a crackly or muffled sound. Today AM radio is used primarily for talk and sports radio due to the quality of the sound.

FM Broadcasting

Edwin Howard Armstrong in 1902 pioneered *FM broadcasting*, a broadcast technology that uses frequency modulation (FM) to provide high-fidelity sound over broadcast radio. Like AM broadcasting, FM radio uses electromagnetic radiation to broadcast sound information. A receiver is used to pick up the radio signal, looking for small changes in the carrier signal on a specific frequency carrying the sound information called the carrier wave. This process enables the listener to hear the information rather than the radio signal like AM radio broadcasting.

Cornelius Ehret, Philadelphia, Pennsylvania, submitted a patent application defining the use of frequency modulation in both radiotelegraphy and radiotelephony that includes circuitry for both FM transmission and reception.[14] Armstrong, in 1934, began testing FM from the Empire State Building using 41 MHz with cooperation from RCA in New York City. He transmitted using both AM and FM. After some

resistance, Armstrong was granted an experimental license for a FM station in 1936.

The first commercial FM broadcasting stations were in the United States. These stations were primarily used to broadcast classical music to an affluent listenership in urban areas and for educational programming. FM broadcasting expanded into other music categories and news by the 1960s as the FCC awarded more FM permits and approved FM stereo multiplex standards.

The advantage FM stations had over AM stations was better quality sound over longer distances. The FM signal is not subject to static, lightning, and spark interference like AM signals. The reason for improved sound quality is that FM is transmitted in the Very High Frequency (*VHF*), 30 MHz to 300 MHz, radio spectrum. VHF radio waves are similar to light since the waves travel in straight lines limiting the reception range to 50 or 100 miles. Under good conductions, such as flat terrain, the waves can travel 150 miles or more. FM stations are spaced 200 kilohertz (KHz) between each other, while AM stations are spaced 9 to 10 KHz away from each other. Since FM is designed to handle audio from 20Hz to 15 KHz, more space is available to place in the audio spectrum twice over, meaning more information on one channel without infringing on the other channel.

The United States, Belgium, Denmark, and Germany were among the first countries to adopt FM widespread. AM stations, in the medium wave band, had become overcrowded after World War II. Top 40 music and country and western music was migrating from AM to FM stations. Many stations simulcast in both AM and FM. With the proliferation of FM stations problems began to occur. A primary issue is that FM receivers are subject to the capture effect causing the radio to receive only the strongest signal when multiple signals appeared on the same frequency. Another concern was that public service broadcasters from Ireland, Australia, and the United States were slow to adopt FM. This created a need for standards on how to use the available FM bandwidth.

The purpose of the standard was to deliver stereo sound using both the left and the right channel of a stereo broadcast on the same FM channel. The process of combining multiple signals onto one composite signal so that the receiver reconstitutes the original signals is called *multiplexing*. The growth in FM stereo broadcasting spurred any many new FM stations starting in 1961.

FM broadcasting is not without its drawbacks. To cover a geographically large area, particularly where terrain is difficult, having a large enough number of FM transmitting stations is expensive. This makes FM more suited for local broadcasting than for nationwide networks in many countries.

Small-scale transmitters can be used to transmit a signal from an audio device such as a MP3 player to a standard FM radio receiver. A transmitter can also be used in near-professional-grade broadcasting systems to transmit audio throughout a property such as a neighborhood or campus radio stations. Campus radio stations are often run over carrier current, also considered a secondary signal transmitted in a "piggyback" fashion along with the main program. This form of broadcasting is called *microbroadcasting*. The reach of FM microbroadcasters is generally less than their AM competitors.

FM subcarrier services are secondary signals transmitted in a "piggyback" fashion along with the main program. Special receivers are required to utilize these services. Analog channels may contain alternative programming, such as reading services for the blind, background music or stereo sound signals. In some extremely crowded metropolitan areas, the subchannel program might be an alternate foreign language radio program for various ethnic groups. Subcarriers can also transmit digital data, such as station identification, the current song's name, web addresses, or stock quotes. In some countries, FM radios automatically re-tune themselves to the same channel in a different district by using subbands.

Radio transmission also occurs by air and water. Aviation voice radios use VHF AM so that multiple stations on the same channel can be received. Aircraft fly at altitudes high enough for their transmitters to receive a signal hundreds of miles away even though they are using VHF. Marine voice radios use a single sideband voice (SSB) in the shortwave High Frequency (HF) radio spectrum (3 MHz to 30MHz) for longer distances than VHF. The reason for the longer distances is that SSB does not transmit the unused carrier and sideband needed for other frequencies. Marine voice radios can also use narrowband FM in the VHF spectrum for shorter ranges.

Early police radios used AM receivers for one-way dispatches. Today, government, police, fire, and commercial voice services use narrowband FM on special frequencies. Civil and military HF voice services also use shortwave radio for communications with aircraft, isolated settlements, and ships at sea.

TELEPHONY—CELLULAR AND SATELLITE PHONES

Cellular Phones

Mobile phones, also known as cellular phones or cell phones, are an electronic device that transmits its signal to a local cell site (transmitter/receiver). The cell site connects to the *public switched telephone network* (PSTN) through an optic fiber, microwave radio, or other network

elements. A PSTN, also known as the *plain old telephone service* (POTS), is a global network of public circuit-switched telephone networks. When the mobile phone nears the edge of the cell site's radio coverage area, the central computer switches the phone to a new cell. Cell phones enable seamless telephone calls whether an individual is stationary are moving around wide areas, such as across the country or a town. Cordless phones, sometimes confused with cell phones, provide telephone services within a limited range using a single base station that is attached to a fixed landline such as that used within a home or office.

Early cell phones used FM; most cell phones today use various digital modulation schemes. Public radiotelephone service on the high seas was introduced in 1929. By 1965, mobile radiotelephone service was widely available in the United States. Dr. Martin Cooper invented the first portable handset in 1973 when he made a call using a portable cellular phone. Dr. Cooper was a former Motorola systems manager. Dr. Cooper setup a base station in New York using the Motorola DynaTac, a cellular telephone prototype to show the public. In 1977, cell phones went public and testing of public cell phones began in Chicago the same year. The test group consisted of 2,000 customers. The testing was expanded to Washington, DC, and Baltimore and then to Japan in 1979.

Demand grew around the world. The cellular phone business started 50 years ago. Today, the cellular business has become a $30 billion per year industry and has more than 60 million users.[15] Globally, mobile phones are considered a necessity. Millions in India, China, Nigeria, and other emerging markets will continue to acquire mobile phones according to the International Telecommunication Union (ITU). In mature markets such as Europe and North America mobile phone use will also continue to increasing replacing fixed-line telephone.

Recent advances in cell phone technology enable an individual, on demand, to download digital material from a radio broadcast (such as a song) to a mobile phone, pay for a service at the point of sale, or request emergency services through an Enhanced 9-1-1 system. *Terrestrial Trunked Radio* (TETRA) is a digital-trunked mobile radio standard developed by the European Telecommunications Standards Institute (ETSI), an advancement in mobile telephony solutions. The purpose of the TETRA standard was to meet the needs of traditional Professional Mobile Radio (PMR) user organizations such as government, military, law enforcement, and EMS.

Satellite Phones

Satellite phones use satellites rather than cell towers to communicate. The two types of satellite phones are *Inmarsat* and *Iridium*. Both satellite

types provide global coverage. Inmarsat uses geosynchronous satellites with aimed high-gain antennas on the vehicles. Inmarsat offers a comprehensive range of global mobile satellite services for use on land, at sea and in the air. Inmarsat services include voice, broadband data communications, and fax via its satellite system. Iridium constellation uses 66 low earth-orbiting (LEO) cross-linked satellites as the cells. Iridium is a global communications network with coverage for the entire planet. Iridium offers mobile voice and data communications.

Navigation

Satellites with precision clocks are used for satellite navigation system. A receiver listens to four satellites, each transmitting its position and the time of its transmission. The receiver then calculates using this information for its position based on a line that is tangent to a spherical shell around each satellite. This is as determined by the time-of-flight of the radio signals from the satellite.

The oldest form of radio navigation is radio direction-finding. Marine radio-location beacons and moveable loop antennas were used to locate commercial AM stations near a metropolitan area. Radio-location beacons were also shared with amateur radio operations for frequency ranges just above AM radio.

Aircraft used *VOR (Very High Frequency Omni-directional Range)* systems that have an antenna array transmitting two signals simultaneously. A directional signal rotates like a lighthouse at a fixed rate. An omni-directional signal pulses when the directional signal is facing north. An aircraft can determine its bearing by measuring the difference in phase of these two signals to establish a line of position. An aircraft can get a "fix" by obtaining readings from two VORs and then locate its position at the intersection of the two radials. Aircraft can also get a fix from one ground station when the VOR station is collocated with *DME (Distance Measuring Equipment)*. This type of station is called a *VOR/DME*. A similar system of navaids is operated by the military called *TACAN*. TACANs are often built into VOR stations, known as *VORTAC*s. VOR/DME and VORTAC stations are similar in navigation potential to civil systems since TACANs include distance-measuring equipment.

RADAR

Radio was used in the prewar years for detecting and locating aircraft and ships via *radar* (*Ra*dio *D*etection *a*nd *R*anging). Radar detects

objects at a distance by bouncing radio waves off the objects. The delay caused by the echo from the object measures the distance. The direction of the beam determines the direction of the reflection. The type of surface can be sensed through the polarization and frequency of the return. Navigational radars, common on commercial ships and long-distance commercial aircraft, can scan a wide area two to four times per minute using short waves that reflect from earth and stone.

Less sophisticated radars are general-purpose radars that use navigational radar frequencies. These devices modulate and polarize the pulse so the receiver can determine from the reflector its type of surface. The more advanced general-purpose radars distinguish the rain of heavy storms, land, and vehicles, and can superimpose sonar data and map data from Global Positioning System (GPS).

Other types of radar include search, targeting, and weather radars. Search radars can scan a wide area with pulses of short radio waves on average two to four times a minute.

Search radars sometimes use the *Doppler effect* to separate moving vehicles from clutter. The Doppler effect is the change in the frequency of energy in the form of waves, such as light or sound, that results from the motion from the source or the receiver of the waives. The Doppler effect was named after Christian Doppler, an Austrian scientist, who demonstrated the effects of sound. When the source of the wave and the receiver are approaching each other, the wave frequency will increase and the wavelength shortened. In short, sounds become higher pitched and light bluer. Conversely, when the source of the wave and the receiver are moving away from each other, the wave frequency will decrease and the wavelength lengthens. This means sounds become lower pitched and light redder.

Targeting radars are much like search radar scanning a smaller area more often, usually several times a second or more. Weather radars are similar to search radars, but use radio waves with circular polarization and a wavelength to reflect from water droplets. Some weather radar use the Doppler effect to measure wind speeds.

Data (Digital Radio)

Radio systems today primarily use digital broadcasting. The oldest form of digital broadcasting was spark gap telegraphy pioneered by Marconi. An operator of the Marconi system would press a key to send messages in Morse code by energizing a rotating commutating spark gap. The receiver would produce a tone from the rotating commutator, such as a hiss, that was indistinguishable from static. A spark gap transmitter broadcasts using a span covering several hundred megahertz (MHz).

These transmitters are now illegal since they waste radio frequencies and power.

Continuous wave (CW) telegraphy was the next advancement in telegraphy. CW uses a pure radio frequency that is produced by a vacuum tube electronic oscillator. The oscillator had an on/off switched that was operated by a key. A whistle-like audio tone was generated by a receiver having a local oscillator that would "heterodyne" with the pure radio frequency. CW use less than 100 Hz of bandwidth and are used by amateur radio operators today.

The military and weather services use radio teletypes that operate on short wave (HF) since it can create written information without a skilled operator. These radio teletypes sends a bit using one of two tones. A group of five to seven bits represents a character printed by a teletype. Aircraft radio-teletype service uses 1,200 Baud over VHF to send its identification, altitude and position. It is also used to obtain gate and connecting flight information. Radio teletype was a primary means of sending commercial messages to less developed countries between 1925 and 1975.

Other areas where radio-teletype service is used are microwave dishes on satellites, telephone exchanges and TV stations leveraging quadrature amplitude modulation (QAM). QAM sends data by changing the phase and amplitude of the radio signal. Engineers like QAM since it bundles the most bits into a radio signal when using an exclusive (non-shared) fixed narrowband frequency range. These bundles of bits are sent in "frames" that repeat. A unique bit pattern is used to locate the start of a frame.

The various radio-teletype communication systems described using fixed narrowband frequency range is vulnerable to jamming. To counter this threat a number of jamming-resistant spread spectrum techniques have been developed. *Global Positioning System* (GPS) satellite transmissions as used by the military are one example. Other spread spectrum for commercial use was deployed in the 1980s. Today, many cell phones, Bluetooth, and Wi-Fi (802.11b version) use various forms of spread spectrum.

GPS is a U.S. space-based radio-navigation system that provides positioning, navigation, and timing services to civilian users on a continuous worldwide basis. This is a free service provided by the U.S. government to anyone. A GPS receiver can receive location and time information from the system for an unlimited number of people, anytime, anywhere, regardless of time of day or weather conditions. The GPS consists of three segments:

- Satellites orbiting Earth
- Control and monitoring stations on Earth
- GPS receivers owned by users

Each GPS receiver gets the latitude, longitude, altitude (location), and time.

Bluetooth, named after Harold Bluetooth, a king in Denmark over 1,000 years ago, is the specification for using low-power radio communications to wirelessly link devices such as personal phones, PDAs, headsets, computers, and other networked devices. Bluetooth devices link up to distances of 30 feet or less and communicate at less than 1 Mbps.

The Institute of Electrical and Electronics Engineers (IEEE) established the standard protocol 802.11 for wireless network. There are three types—802.11a, 802.11b, and 802.11g. The first version is 802.11b, which is slower and less expensive than the other types and operates on frequency 2.4 GHz and transfer speeds up to 11 Mbps. 802.11a is the next generation wireless network operating on frequency 5 GHz with transfer speeds up to 54 Mbps. The third type is 802.11g, a combination of 802.11a and 802.11b wireless networks operating on frequency 2.4 GHz with a transfer speed up to 54 Mbps.

Both Bluetooth and Wi-Fi are wireless technologies that use radio frequency waves to create networks. Bluetooth temporarily connects an individual personal device over a short distance creating what is called a *personal area network* (PAN). The PAN enables devices in the immediate area to join the network. Wi-Fi connects multiple computers, desktops, laptops, and PDAs, over longer distances. The Wi-Fi Alliance, an international association, certifies interoperability of wireless Local Area Network (LAN) products based on IEEE 802.11. According to the Alliance on every continent, one in ten people around the world use Wi-Fi at home and work in countless ways.

Another resource is *coded orthogonal frequency-division multiplexing (COFDM)*. COFDM is a computer-aided system that makes and decodes signals, resists fading and ghosting, has error-correction coding, can resist interference, and is an adaptive system. COFDM is used for Wi-Fi, some cell phones, *Digital Radio Mondiale*, Eureka 147, local area networks (LANs), digital TV (DTV), and radio standards.

Digital Radio Mondiale™ (DRM) is the universal, open-standard, digital broadcasting system for all broadcasting frequencies up to 174 MHz, including AM and FM bands. The Eureka 147 System is the worldwide standard for both terrestrial and satellite delivery and will eventually replace traditional FM services. A LAN is a computer network connecting computers and devices within a limited geographical area such as a home, school, or office building. DTV is the transmission of video and audio by discrete (digital) signals.

Unlicensed Radio Services

Throughout North America, government authorized personal radio services such as Family Radio Service, Citizens' Band Radio, Multi-Use

Radio Service, and other radio services offer short-range, easy-to-use communications for small groups without licensing overhead. Similar services are used around the world.

Unauthorized, unlicensed radio broadcasting does occur and is called *pirate* or *free radio*. *Free radio* does not advertise or make money, while *pirate radio* broadcasting does advertise and make money to exist. Pirates are usually hobby broadcasters operating for entertainment by their owners and broadcasts are seldom political in nature.

Radio Control (RC)

Radio remote controls use radio waves to transmit control data to a remote object as in some early forms of guided missile, some early TV remotes and a range of model boats, cars and airplanes. Large industrial remote-controlled equipment such as cranes and switching locomotives now usually use digital radio techniques to ensure safety and reliability.

In Madison Square Garden, at the Electrical Exhibition of 1898, Nikola Tesla successfully demonstrated a radio-controlled boat. He was awarded U.S. patent No. 613,809 for a "Method of and Apparatus for Controlling Mechanism of Moving Vessels or Vehicles."

Wireless

In recent years the term "wireless" has gained renewed popularity through the rapid growth of short-range computer networking, for example, Wireless Local Area Network (WLAN), Wi-Fi, and Bluetooth, as well as mobile telephony, for example, GSM and UMTS. Today, the term *radio* often refers to the actual transceiver device or chip, whereas *wireless* refers to the system or method used for radio communication. Hence, one who talks about radio transceivers and Radio Frequency Identification (RFID) may actually be talking about wireless devices and wireless sensor networks.

One of the first developments in the early twentieth century (1900–1959) was that aircraft used commercial AM radio stations for navigation. In the early 1930s, amateur radio operators invented single sideband (SSB) and frequency modulation (FM). By the end of the decade, they were established commercial modes. In 1954, Regency introduced a pocket transistor radio, the TR-1, powered by a "standard 22.5 V Battery." In 1960, Sony introduced its first transistorized radio, small enough to fit in a vest pocket and able to be powered by a small battery. It was durable, because there were no tubes to burn out.

Today, a digital cell phone system, called *Terrestrial Trunked Radio* (TETRA), is used for military, police and emergency medical services. Commercial services such as *XM* (a pay-for-service satellite radio operator in the United States and Canada), WorldSpace (International satellite radio operator), and Sirius (a satellite radio (SDARS) service operating in the United States and Canada) offering encrypted digital satellite radio. In 2008, XM and Sirius satellite companies merged. The new organization called for the provision of satellite digital audio radio service (or "SDARS") in the United States, which would benefit consumers by offering more programming choices at various price points and greater choice and control over the programming subscription selected.

Other Radio

Energy autarkic radio technology consists of a small radio transmitter powered by environmental energy (push of a button, temperature differences, light, vibrations, etc.). A number of schemes have been proposed for wireless energy transfer. Various plans included transmitting power using microwaves. *Microwave power transmission* is the process of using microwaves to transmit power through space without wires. These schemes include, for example, solar power stations in orbit beaming energy down to terrestrial users.

Early radio systems relied on the energy collected by an antenna to produce signals for the operator. Radio became more useful after the invention of electronic devices such as the vacuum tube. The transistor later extended the use of radio, making it possible to amplify weak signals. Today, radio systems are used for applications from walkie-talkie children's toys to the control of space vehicles, as well as for broadcasting, and many other applications.

Radio assumes many forms today, including wireless networks and mobile communications of all types and radio broadcasting. Before the advent of television, commercial radio broadcasts included news and music, dramas, comedies, variety shows, and many other forms of entertainment. Radio was unique among methods of dramatic presentation in that it used only sound. For more, see radio programming in Section B, AM Broadcasting.

Television

Radio became an old medium with the arrival of television. Television is a telecommunications medium for transmitting and receiving moving

images. The term *television* was a new word coined by the French and Constantin Perskyi, a Russian scientist, in 1900. After much effort, John Logie Baird transmitted the first experimental television signal in 1925 using radio to send pictures visible as television. Television offered live broadcasting of what was being recorded. In 1938, television broadcasts were taped, edited, and transmitted later. Scheduled television programming was introduced in 1939. Commercial television transmissions across North America and Europe occurred in the 1940s.

Television sends the picture as AM and the sound as FM, with the sound carrier a fixed frequency (4.5 MHz in the National Television System Committee [NTSC] system) away from the video carrier as used by many countries in the Americas. NTSC system establishes video bandwidth at 4.2 MHz and sound carrier at 4.5 MHz. Analog televisions uses a vestigial sideband on the video carrier to reduce the bandwidth required.

Digital television uses 8*VSB* modulation in North America (under the Advanced Television Systems Committee (ATSC) digital television standard), and coded orthogonal frequency-division multiplexing (COFDM) modulation elsewhere in the world (using the Digital Video Broadcasting–Terrestrial (DVB-T) standard). 8VSB, denoted as 8-level Vestigial Side Band (VSB), is the transmission method for HDTV. *Terrestrial* means to send over the air. A Reed-Solomon error correction code adds redundant correction codes and allows reliable reception when moderate data loss occurs.

Many *codecs,* a computer program able to encode or decode a digital signal or data stream, can be sent in the MPEG-2 transport stream container format. *MPEG*-2 represents digital television signals that are broadcast terrestrial, cable, or by direct broadcast satellite. High-definition television (HDTV) is possible simply by using a higher-video resolution picture. HD has one or two million pixels per frame. Standard-definition TV (SDTV) has 720 pixels for 480 lines, roughly five less than HDTV. With compression and improved modulation offered by HD over SD, a single channel can have a high-definition program and several standard-definition programs.

With the majority of the world's population focused on agriculture and manufacturing, illiteracy remained a problem in the early 1900s. In 1910, only 24% of U.S. adults had 5 years of education, 13.5% had completed high school, and 2.7% had a college degree. In the early 1960s, an estimated 44% of the world's population was illiterate and in the United States, 90% of households had a television set. The high level of illiteracy in the United States and the growing use of televisions in the home for entertainment led then FCC chairman Newton Minow in 1962 to call television a "vast wasteland."

Despite Chairman Minow's views of television, the FCC continued its role in the regulation and the advancement of related technology. In 1962, the FCC required television sets to have UHF tuners. By 1963 television news was so much the choice of the people that most learned of President John F. Kennedy's assassinaton by this medum. TV news was coming of age. By 1965, most television broadcasts were in color. Television sets were in the homes and businesses of 200 million around the world at a time when the United States had a population of 78 million. With the use of satellites for broadcasting, the first words from the moon "That's one small step for man; one giant leap for mankind"[16] as said by Neil Armstrong, Apollo 11, in 1969, were heard through this technology.

The FCC promotes use of *digital television (DTV),* a technology using digital signals to transmit television programs rather than analog signals. DTV that allows for the transmission of better quality sound and higher resolution pictures is referred to as *high-definition television* (HDTV). HDTV was first developed in Japan by NHK in 1964. Fifty years later, in 2009, FCC required all television stations to broadcast only in digital in the United States. Television has been used as a communication medium to deliver emergency communications through live and recorded coverage of an event.

Satellites

Live television broadcasting for global audiences began with the introduction of the first international communication satellite that could transmits images called Telstar in 1962. As Telstar and other satellites were launched into orbit an international satellite organization was formed called Intelsat in 1964. By 1965, satellites began domestic TV distribution in the Soviet Union and the commercial communications satellite "Early Bird" also known as "Intelsat I" went into orbit. By 1968 Intelsat I had completed its global communications satellite loop. Shortly thereafter, the first television programming was available nationwide using a satellite as placed into operations by Ted Turner.

Over the next 20 years, transistors replaced tubes almost completely except for very high-power uses. By 1963, color television was being regularly transmitted commercially, and the first (radio) communication satellite, TELSTAR, was launched. In the late 1960s, the U.S. long-distance telephone network began to convert to a digital network, employing digital radios for many of its links. In the 1970s, *LORAN* (acronym for *Long Range Navigation*) became the premier radio navigation system. LORAN is a terrestrial radio navigation system that uses low-frequency radio transmitters for navigation.

Soon, the U.S. Navy experimented with satellite navigation and launched the GPS constellation in 1987. It became a replacement system for the LORAN since GPS systems offered greater accuracy. In the early 1990s, amateur radio experimenters began to use personal computers with audio cards to process radio signals. In 1994, the U.S. Army and the *Defense Advanced Research Projects Agency* (DARPA) launched an aggressive, successful project to construct a software-defined radio that can be programmed to be virtually any radio by changing its software program. Digital transmissions began to be applied to broadcasting in the late 1990s. DARPA is the research and development section for the U.S. Department of Defense that is focused on technology for the military and preventing technological surprises from harming national security.

Information Science and Computers

At the end of World War II, the global population grew rapidly, and the many ways to communicate paralleled this increase. In the United States, populations were sprawling into suburban areas. There was a shift from an agricultural and manufacturing society to a technology and information society was well under way. In 1941, Konrad Zuse of Germany developed the Z3. This was a fully program-operational calculating machine introduced in Berlin. In the 1940s, the information science age began, when the first government-owned computers were placed into public service in 1944. By 1946, the ENIAC was completed (see Figure 1.5 ENIAC). ENIAC was among the first computers. It covered more than 136 square meters, used 18,000 vacuum tubes, and could compute 5,000 numbers ten digits in length per second. It was created for the army to compute World War II ballistic firing tables. The ENIAC was completed before the Manchester Mark 1.

FIGURE 1.5 ENIAC.

Information science is concerned with the ways in which the human experience is structured, represented, managed, stored, retrieved, and transferred later. Harvard University-IBM Mark I computer was among the first computers used for public service. By late 1949, the Harvard Mark III was 25 times faster than the Harvard Mark II, and 250 times faster than its predecessor.

The 1950s began with the first commercialized computers for business such as the UNIVAC. The first graphical computer game was also developed call "OXO" for tic-tac-toe by Alexander Sandy Douglas on an EDSAC. IBM mass-produced the IBM 650 and introduced an early formula translator called FORTRAN. Computers became faster, smaller, cheaper, more reliable, and generated less heat with the introduction of Bell Labs' transistor computers. The first video game was created by William Higinbotham called *Tennis for Two*. The number of computers that were in use by academia, the government and businesses grew astronomically. By 1968, Intel had introduced an Intel 1 KB RAM microchip into the marketplace.

People, now wanted to use computers like they had in the office at home. By 1976, Apple Computers had invented the Apple I, the first home computer. Unlike its predecessors, the Apple I was preassembled, included a TV interface with built-in support for a keyboard and later could store information to a cassette recorder. Eight years after the first home computer was released, in 1984, International Business Machines (IBM) introduced its personal computer called the IBM PC AT. The IBM PC AT had the power of a word processor, brand-name recognition and acceptance, and was far more powerful than the Apple I.

IBM in early 2000 sold its PC brand to Lenovo including the popular ThinkPad. ThinkPad was a durable laptop introduced in the 1990s. Apple Computers now offers a number of new computing technologies, iMacs (desktop) and iPads (tablets), computing devices you can fit neatly in a binder or purse.

The number of computers that were in use by academia, the government, and businesses grew astronomically. The need for increased power and processing speed to handle more data for research, commerce, and daily business processes led to the creation of a local area network (LAN). A *LAN* is a computer network that connects computers and devices that are in close proximity such as a home, school, computer laboratory, or office building. LANs were initially for atomic weapons research in 1964. These new capabilities lead to a revolution in information technology—the advent of the first Internet known as *ARPANET* (Advanced Research Projects Agency Network) in 1969. ARPANET was the first wide-area packet switching network. *Packets switching* are small blocks of data sent over a dedicated line. ARPANET was a computer

networking research project that was to provide a secure and survivable communications system in case of war.

INTERNET

ARPANET began as connections among University of California–Los Angeles, Stanford Research Institute, the University of California–Santa Barbara, and the University of Utah. Twenty years later, the U.S. government released control of the Internet and the World Wide Web (WWW) was born. ARPANET expanded and other fields began to use it and the private sector including businesses like Dow Chemicals. A program to send electronic mail, known as *e-mail,* was developed in 1971. By 1973, Britain and Norway provided the first international connections to the system. Mailing lists, newsgroups, and electronic bulletin board systems (BBS) were established, and TCP/IP was adopted as the communications protocol in 1982. In 1986, the National Science Foundation established the NSFNET, a distributor of networks capable of handling more traffic. Within a year, more than 10,000 hosts were connected to the Internet.

In 1988 real-time conversations via the network was possible using the newly developed Internet Relay Chat protocols. Dial-up access for commercial access started in 1990 as ARPANET was deactivated. A year later, in 1991 the World Wide Web was publicly available using FTP. By 1997, there were more than 10 million hosts on the Internet and more than 1 million registered domain names. Traditional Internet access was granted by using dial-up across public telecommunications (telephone) network. Internet access was expanded to include radio signals, cable-television lines, satellites, and fiber-optic connections, though most traffic still uses a part of the public telecommunications (telephone) network.[17]

COMMUNICATIONS FOR PEOPLE WITH DISABILITIES AND OTHERS WITH FUNCTIONAL AND ACCESS NEEDS

Communications for people with disabilities and others with functional and access needs began to take shape at the start of the twentieth century. This segment of the population have historically be referred to as "special needs populations," "vulnerable populations," or "at risk" populations to defined groups having unique needs that may not be addressed using only traditional approaches. These populations include those who are physically disabled, mentally disabled, hearing impaired (deaf and hard of hearing), visually impaired (blind, unable to see at night or different colors or shapes), cognitively impaired, and mobility challenged. Other groups that may qualify include those

who are non-English speaking (or not fluent in English), culturally or geographically isolated, homeless, medically or chemically dependent, children and the elderly. Technology developed to support the communication needs of this population included hearing aids for the hearing impaired and Braille for the visually impaired. The history of these and other adaptive technologies are discussed below.

Hearing Impaired

Two key technologies were commercialized in the twentieth century for the hearing-impaired. These technologies opened new and affordable methods for people who are hard of hearing or unable to hear to communicate with others—the hearing aid and Text Telephone services.

Hearing Aid

The *hearing aid* started as a big, bulky apparatus that amplified sound. The early hearing aids were huge, horn-shaped trumpets with a large, open piece at one end to collect sound. The trumpet gradually narrowed into a thin tube that funneled the sound into the ear. Using Thomas Edison's carbon transmitter invented in 1886 and Alexander Graham Bell's electronically amplified sound in his telephone using a carbon microphone and battery influenced a new generation of hearing aids.

A new concept emerged—an electronic apparatus changing sounds into electrical signals that could travel through wires and be converted back into sounds. This concept was adopted by hearing aid manufacturers and used in the first hearing aids of the twentieth century. By 1901, Alexander Graham Bell, improving communications for the hearing-impaired, developed a new hearing aid. Over time, the hearing aid has become smaller. By 1952, hearing aids went from an electronic apparatus with large batteries and vacuum tubes designed to fit within eyeglass frames to devices fitting behind the ear using transistors.

Text Telephone

A deaf physicist named Robert Weibrecht developed the *text telephone* called *TTY* in 1964. TTY is a device that enables the hearing impaired or speech-impaired to type messages back and forth with the caller rather than talking and listening. To use TTY both the sender and the receiver must have the equipment. TTY is sometimes called the "Telecommunication Device for the Deaf" or TDD. Of the three terms, TTY is most widely accepted.

Advancements in technology led to the *Telecommunications Relay Service* (TRS). TRS is a service providing a trained operator who types what is said so that receivers can read the message on their TTY display

and type a response. The TRS operator will read aloud the message to the party on the line. TRS services are available 24 hours a day, 365 days a year, and are toll free.

Speech Impaired

In 1960, a voice communication device for individuals who could not speak called the *electronic larynx* was introduced. The larynx is the voice box of mammals, including humans, which manipulates the pitch and volume of our voice. An electronic larynx, also known as a "mechanical larynx" or "throat back" is a speech aid used to produce intelligible speech for those whose voice box is not functioning properly.

Visually Impaired

Braille

Louis Braille, born in 1809 near Paris, was injured while playing in his father's shop. The affected eye became infected and left him blind. Louis learned of a raised dots system developed by Charles Barbier de la Serre, a French army captain. To write and read messages at night without using a light that could give away their positions, soldiers used Barbier's system.

Barbier's system was built using phonetics with groups of raised twelve dots arranged in two columns of six dots each. Louis modified Barbier's system to develop his own simplified system known today as *Braille*. Braille uses the standard alphabet and reduced the number of dots by half that can be read by touch. The first Braille book was published in 1829. In 1837, math and music symbols were added. Braille is the standard form of reading and writing used by those who are visually impaired. It is a common form of communication in the blind culture, in virtually every language around the globe, and is unique to the blind.

Braille can be produced in-house with the right software, training, and embosser. Braille translation software can translate information on a computer screen into Braille that the user reads on an adapted keyboard. Various cassette recorders/players are used to record and listen to data or information.

Elderly

The *elderly* are often said to be those who are 65 years of age or older. At the start of the twentieth century, life expectancy of this age group was short and many lived in extended family settings with one or more of the

children. The literacy rate was low; many had reading skills of the 6th grade or less. Some became "snowbirds"—those who temporarily move away from colder climates in the winter months to warmer climates. Others move to other regions of the world for a reduced cost of living and access to services and cultures not available in their home residence. This relocation sometimes takes older people far away from family and familiar settings when an emergency occurs. The 1970s brought push-button telephones with large displays and commercialization of life-alert devices. These devices were installed near the telephones in the homes. If one were to need emergency assistance, they could go to this device and press one button that would dial a calling center that would alert local first responders, usually summoning medical attention.

SUMMARY

Communications mediums have evolved as humankind has evolved. Early humankind was focused on the basics of survival and where communications was limited to small groups over short distances. Early communications began with the establishment of a system that two or more could use for comprehending what was said; later information could be shared in written forms starting with simple pictures and an alphabet. As humankind started developing and using tools, many of its tools began to take on meanings expanding from their original purpose, such as the horns of a buffalo or the metal shield used by soldiers, and were adapted as tools to warn people across distances. Electronic communications expanded this reach with the first transatlantic telegram using Morse code over wire and later with the telephone. The telephone transformed the world. With the twentieth century came significant advancements in broadcasting on the big screen live events to on-demand pre-recorded broadcasts. Communications were tailored so that multiple population subgroups with varying needs and capacities could comprehend a single message using the tool that was most effective for them such as the radio broadcast of a message that is also available on the web, on television, or on a cell phone. The history of communications mirrors the advancement of humankind.

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