Preparing the Way

Technological Development in the Nineteenth and Twentieth Centuries

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Near the end of the historic worldwide priesthood leadership training broadcast on January 11, 2003, Gordon B. Hinckley, President of The Church of Jesus Christ of Latter-day Saints, noted that "the Lord has made possible the technology by which this training is going forward."[1] It was also noted that the priesthood leadership training was being broadcast in real time, via satellite, to all parts of the world, with the exception of west Africa, a geographic area which did not fall in the satellite footprint. One wonders if Isaiah foresaw these technological capabilities when he wrote "for out of Zion shall go forth the law, and the word of the Lord from Jerusalem" (Isaiah 2:3).

Prophets have foretold that this, "the dispensation of the fulness of times" (Ephesians 1:10; see also D&C 121:26–32), the final era in the history of the planet earth as we know it, will be a time when all truth is revealed, both spiritual and temporal. This dispensation was ushered in when a fourteen-year-old boy named Joseph Smith entered a grove of trees in upstate New York in the spring of 1820.

One only has to look at the plethora of modern conveniences and technologies to realize that we live in the dispensation of the fulness of times. People can communicate instantaneously across great distances, people can travel around the world with ease, and people are living longer, healthier lives. It is clear that technology and technological innovations have dramatically changed how *and* where we live, learn, work, play, and worship.

The marvels of technology have, in most instances, made life and work much easier, albeit more complex. President James E. Faust noted at the October 1999 general priesthood meeting that "the miracles of modern technology have brought efficiency into our lives in ways not dreamed of a generation ago, yet with this new technology has come a deluge of new challenges to our morals and our values."[2]

Technology, its products, and its benefits have ushered in a new age of materialism in which people have embraced the concept that the person who acquires the most toys wins. Such aspects of technology challenge our values and morals as people rely more on technology to solve problems rather that relying on God. This concern is not limited to President Faust and our Church. To counteract the detrimental effects of technology, some religious groups have made the relationships between technology and theology a point of doctrine. For example, the Amish reject many modern technological advances like automobiles, television, electricity, and modern clothing fashions in an attempt to maintain a strong focus on God.[3]

What Is Technology?

Technology, by its very nature, touches all facets of society. We increasingly rely on technological systems and devices to communicate with others, to grow and process our food, to manufacture goods, to automate systems in our homes and businesses, and even to entertain ourselves. Charles Gagel supports the notion that technology is a universal, commenting that "there is a dimension of technology, like literacy, that is culturally universal; . . . the ubiquitous occurrence of technology (like language) in human cultures."[4] The universal, society-permeating nature of technology makes it very difficult to define. Hence, there are many conceptions and misconceptions of technology.

Many people consider "technology" and "computers" to be one and the same. This perspective is, however, shortsighted. Computers are technological devices, that people use to extend their capabilities, but technology is much more than just computers. Considering technology and computers to be synonymous would be analogous to considering football and sports to be the same—a very limited perspective that ignores the wide array of personal and team sports available. Yes, computers are included in the scope of what technology is, just as football is included in the scope of what sport is. But both technology and sports are much broader than just computers or football.

Today there does not seem to be a clear definition of technology. The term has many meanings. To some it means "applied science," to others it means "gadgets, devices, and machines," and to yet others it means "a complex social enterprise or process." What then is technology? First, a highly regarded dictionary defines technology as "1. application of tools and methods . . . ; 2. method of applying technical knowledge . . . ; 3. sum of a society's or culture's knowledge."[5]

There are two words in this definition that resonate—*knowledge* and *application*. It is interesting to note that John H. Gibbons, when he was director of the U.S. Congress's Office of Technology Assessment, defined technology as "applied human knowledge," which is probably the most succinct definition of the word.[6]

The Committee on Technological Literacy (CTL), a prestigious national panel in the United States that was jointly appointed by the National Research Council (NRC) and the National Academy of Engineering (NAE), broadly defined technology as "the process by which humans modify nature to meet their needs and wants."[7] In their report, *Technically Speaking: Why All Americans Need to Know More about Technology*, they also included an adaptation of Mitchem's perspective, stating, "Technology comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves."[8]

Thus, technology is pervasive—it is the entire system; it is knowledge, processes, and devices; it is creating and operating artifacts. Technology includes artifacts (for example, computers, devices, tools), but it is more than just artifacts—it also includes systems, knowledge, and will.[9] Technology should be thoughtful action, based on human values with the purpose of extending human capabilities. As noted earlier, technology is "applied human knowledge," or it might also be considered "human innovation in action."

Science

What, then, is science? Basically it is "the study of the physical world and its manifestations, especially by systematic observation and experiment."[10] It is knowledge of natural phenomena.

Science and technology are different, but they work together in a symbiotic manner. Whereas science is the study and understanding of natural phenomena, technology is the use of resources to extend human capabilities. Science makes use of the scientific method, including observation and experimentation, as the means for discovering new phenomena and new knowledge. Technology uses design, trial and error, and engineering methods to develop new uses and applications of technology. Often the application of new scientific discoveries facilitates the development of new technologies. Likewise, technological advances, such as the electron microscope, provide the means for furthering scientific discoveries.[11]

While technology and science are symbiotic and often synergistic, Rustum Roy notes that historically technology often preceded science. He further noted that science often has more status than technology. For example, he noted that the general population has been led to believe that it was American science that won World War II. Roy stated: "If science conferred any advantage, Germany should have won hands down. Making nuclear bombs was an enormous technological achievement, based on the U.S. enormous technology base in power, people, and resources. Yet the historical fact remains that just as Jacob stole Esau's blessing by sleight of hand (Genesis 27:27–34), a much more serious stealing of the birthright (the affection of the U.S. public) of 'technology' by 'science' occurred in the late forties. This misrepresentation—this golden fleecing à la Senator Proxmire of stealing the kudos due to technology—has, does, and will, until rectified, cost the nation very dearly."[12]

Characteristics of Technology

A. E. Wiens and K. S. Wiens identified several characteristics of technology including that it is pervasive, irreversible, cumulative, and powerful. They also note that technology is the modification or control of the environment and that it alters our perceptions of time and space; technology leads to human dependency on it.[13]

Space does not permit a detailed discussion of each of the above characteristics. As an example, however, Wiens and Wiens note that technology is often irreversible. That is, once deployed, it is difficult to go back or to live without it. Take for example automobiles. How many of us want to go back to the days of the horse and buggy? Do you have any idea how many tons of horse manure were generated daily by horse-drawn cabs just in New York City at the turn of the last century? Would we want to go back to cars without air-conditioning in the summer? Or without things like power door locks and remote keyless entry? What about computers or photocopiers? Or CD and DVD players?

Another illustration of one of the above characteristics is the pervasive nature of technology and the change it brings. Neil Postman noted that technology brings systemic and pervasive change: "A new technology does not add or subtract something. It changes everything. In the year 1500, fifty years after the printing press was invented, we did not have old Europe plus the printing press. We had a different Europe. After television, the United States was not America plus television; television gave a new coloration to every political campaign, to every home, to every school, to every church, to every industry."[14]

The Source of Technology

The Committee on Technological Literacy noted that technology is "closely associated with innovation."[15] This perspective is consistent with the International Technology Education Association's conception of technology as being "human innovation in action."[16] "Innovation" suggests knowledge-based creative thought and action. The question then becomes what is the source of human innovation? Is it studying at the greatest universities? Is it working in the greatest industry research centers?

As we consider the development of technology and science, it is interesting that many of our Church leaders believe that technology has come as a direct result of inspiration from the Lord. President Brigham Young noted that "there is no ingenious mind that has ever invented anything beneficial to the human family but what he obtained it from that One Source."[17] Likewise, Elder Joseph Fielding Smith strongly believed that inventions come as a result of inspiration from God. Elder Smith noted this in the October 1926 general conference:

> I maintain that had there been no restoration of the gospel, and no organization of the Church of Jesus Christ of Latter-day Saints, there would have been no radio; there would have been no airplane, and there would not have been the wonderful discoveries in medicine, chemistry, electricity, and the many other things wherein the world has been benefited by such discoveries. Under such conditions these blessings would have been withheld, for they belong to the Dispensation of the Fulness of Times of which the restoration of the gospel and the organization of the Church constitute the central point, from which radiates the Spirit of the Lord throughout the world. The inspiration of the Lord has gone out and takes hold of the minds of men, though they know it not, and they are directed by the Lord. In this manner he brings them into his service that his purposes and his righteousness, in due time, may be supreme on the earth. . . .
>
> I do not believe for one moment that these discoveries have come by chance, or that they have come because of superior intelligence possessed by men today over those who lived in ages that are past. They have come and are coming because the time is ripe, because the Lord has willed it, and because he has poured out his Spirit on all flesh.[18]

This statement was made in 1926. As we contemplate the technological innovations since that time we can see the Lord's hand in providing the technologies to further His work.

Prominent Latter-day Saint scholar Hugh Nibley has likewise affirmed that the source of human innovation and ingenuity is divine "The Greeks were greatly impressed by the fact, attested by long experience, that even the greatest genius cannot create at will. The moments of genuine creativity are simply not within human control, all that is within human control being what Plato calls mere imitation—i.e., something that can be taught—for to learn is simply to imitate. Even when they create by inspiration, however, humans know that the result is but a poor reflection of the divine original."[19]

The Purpose of Technology

President Faust has noted that technological wonders have come to further the work of the Lord. "I hasten to add that scientific knowledge, the marvels of communication, and the wonders of modern medicine have come from the Lord to enhance His work throughout the world. As an example, the Church's FamilySearch Web site has more than seven million hits a day."[20]

Early leaders of the Church embraced technology as a means for doing the work of the Lord. For example, in 1861 President Brigham Young contracted to build the telegraph system from Nebraska to California. He also used this opportunity to build a telegraph line from southern Idaho to northern Arizona in order to communicate with members in the Intermountain West. Adopting this new technology provided a means for the Church to communicate with the world.[21]

President George Albert Smith also believed that technological development has come to further the work of the Lord. After describing several technological advances, including radio and air travel, he stated: "We ought to regard these inventions as blessings from the Lord. They greatly enlarge our abilities. They can indeed become blessings if we utilize them in righteousness for the dissemination of truth and the furtherance of the work of the Lord among men. The great challenge facing the world today lies in the use we make of many of these inventions. We can use them to destroy, as we have sometimes done, in the past, or we can utilize them to enlighten and bless mankind, as our Heavenly Father would have us do."[22]

Church leaders have always placed a premium on communication technologies. I remember as a young deacon in the late 1950s traveling with my father and grandfather to the stake center in Chicago each April and October to listen to the telephone wire transmission of the general priesthood meeting. Can you imagine being twelve years old, sitting on a hard pew, and *listening* to a conference session over the PA system? What a joy it was when WGN-TV in Chicago decided a few years later to broadcast one hour of general conference on Sunday morning! The general priesthood meeting, of course, was still a sound-only telephone transmission.

When cable TV was emerging in the 1970s, many local community cable systems throughout the nation carried all or part of general conference as a public service. Then, beginning in the early 1980s, stake centers were equipped with satellite dishes, which enabled the reception of all conference sessions in real time. Since the late 1990s, members worldwide have access to general conference via the internet, in their native languages!

Using modern communication technologies to distribute general conference worldwide is but one example of how the Church embraces new technologies. Other examples include the use of computers in family history research, in the tracking and updating of membership records, and in the general administration of the Church. For example, in the late 1960s the Church had difficulty handling three thousand membership record changes and updates per day—all done by hand. It could take up to four months for changes to be recorded and verified. Today, membership record updates can be submitted electronically on Sunday and clerks can have verification by Tuesday of the same week—and we are more than twelve million members and growing!

While technology can be used to benefit the Lord's work in its purpose of bringing to pass the eternal life and exaltation of mankind, it can likewise be used by the adversary to benefit his purposes of destroying goodness and stopping the eternal progression of mankind. Elder Faust noted: "Satan, of course, is aware of this great progress in technology and likewise takes advantage of it for his purposes, which are to destroy and despoil. He delights in the pornography on the Internet and the sleaze in many of our movies and television shows."[23] The use mankind makes of God-given technology is the great challenge of our times. One must have faith that, under divine auspices, the good uses of technology will ultimately prevail over its evil applications.

The Industrial Revolution

Significant changes were taking place in England in the latter part of the 1700s. Changes in agricultural production led to people moving from farms to cities. This provided a significant workforce, which, along with the mechanization of manufacturing, helped to fuel the industrial revolution. England, with its vast trading empire, was the strongest commercial nation at the time; it was therefore inevitable that the nation with the most wealth would lead in this revolution.

An ample supply of coal and iron ore and a workforce available to mine it and to work in factories were key ingredients for England's initial dominance as an industrial power. James Watt's invention of the steam engine provided for the use of coal as a new source of energy. In addition, English inventors developed various machine tools that were designed to build machines for factories. John Wilkinson, known as the Ironmaster, was the first to demonstrate that coke made from coal could be used in place of charcoal to produce quality iron on a large scale. He also invented the cylinder-boring machine that made Watt's steam engine a practical source of power.[24] Other English machine tool inventors included Henry Maudslay, who invented a large screw-cutting lathe. The micrometer for the bench work on this machine was accurate to 1/10,000 of an inch. Maudslay had a long-lasting influence on the British machine tool industry.[25]

Mechanization in textile manufacturing, such as John Kay's flying shuttle, Richard Arkwright's water frame, and James Hargreaves spinning jenny, improved the quality and decreased the costs for textiles and also increased the profits for the manufacturers and their investors.[26] These and similar advances dramatically changed how and where goods were produced. The results led to an improved standard of living in England.

It is interesting to note that religion had an impact on the industrial revolution in England. Jim Platts, a professor at Cambridge University, noted that 10 percent of the innovators in the industrial revolution were Quakers, yet Quakers accounted for only 0.2 percent of the population of England, Wales, and Scotland at that time.[27] Quakers, as nonconforming protestants, had several restrictions placed on them by English law. One such restriction was that "no protestant person could enter any of the professions or go to university." It was this constraint which helped create the industrial revolution, "as it made industry the only part of life to which these people could direct their creative energy."[28]

Technology Development in the United States

In the 1700s the vast natural resources, a free enterprise system, and hardworking people seeking a better life laid the foundation for the United States and fueled the industrial revolution in that country. The result has been the development of a society and nation that is unparalleled in economic power. The work ethic and practical problem solving ability of the people, historically referred to as "Yankee ingenuity," fueled the birth and growth of this nation.[29]

Yankee ingenuity was the result of enterprising people who sought, and found, innovative solutions to practical problems. These innovators' education was often limited to primary school, but they had a wealth of practical experience gained through working on the farm or in solving problems to conquer the frontiers.

The American system of manufacture with interchangeable parts, agriculture mechanization, water transportation, railroads, eletromagnetics and electricity, auto transportation and roads, steel manufacture, petroleum refining, and so forth has provided practical technological solutions to many problems.[30] While the significant number of technological innovations Americans have made over the past two centuries is extensive, time will not permit an in-depth discussion of each. However, a key innovation that helped fuel the technological revolution in America, practical education, and developments in communication and transportation technologies will be addressed in subsequent sections of this paper.

Advanced technologies are critical to societies, governments, and nations. In a message to the U.S. Congress on February 22, 1955, President Dwight D. Eisenhower spoke of the strategic role of communication and transportation technology in sustaining the nation: "Our unity as a nation is sustained by free communication of thought and by easy transportation of people and goods. . . . Together, the uniting forces of our communication and transportation systems are dynamic elements in the very name we bear—United States."[31] The economic vitality and the unity of the U.S. has been the result of significant advances in both communication and transportation technologies.

As noted earlier, knowledge and application are central to technology. While knowledge and practical applications are enablers for technological development, it is clear that significant technological advances have come with increasing rapidity since the early 1800s. The advances alone in communication and transportation since the early 1800s have been astounding, which coincides with the ushering in of the dispensation of the fulness of times. This further confirms Joseph Fielding Smith's 1926 declaration that modern technologies belong to the dispensation of the fulness of times.

Practical Education and Technological Knowledge

As the industrial revolution was dawning in America, it is interesting to note that a focus on practical education was also dawning. In 1824 Stephen Van Rensselaer established a school for the teaching of practical subjects, Rensselaer Polytechnic Institute. This unique school, with a focus on "learning by doing," provided courses in "the natural sciences, agriculture, domestic economy, the arts, and manufactures."[32]

Other practical schools were established in this growing nation. Most notable were the land grant colleges, established in each state under the authorization of the Morrell Land Grant Act of 1862.[33] Under the land grant act, each state was given thirty thousand acres of federal land for each senator and representative from the state to be used to develop and operate a practical college that would focus on agriculture and mechanics (engineering). The result has been astounding in terms of the applied research and the technology transferred from these colleges. For example, the practical research in agriculture production and mechanization, in large part attributable to these colleges, has made it possible for the nation to move from an economy where more than 70 percent of the population worked in production agriculture when the land grant colleges were founded to where less than 3 percent do so today—and that 3 percent can produce food and fiber to meet the nation's needs with enough to spare to help feed the world.[34] The land grant universities are an integral component of what has become a world-class higher education system in the United States.

Of course, higher education should not stand on its laurels. Higher education should be the engine that powers the nation as we enter the information age. Nicholas Negroponte noted the role that higher education can play in fostering new ideas: "Research and innovation will need to be housed in those places where there are parallel agendas and multiple means of support. Universities, suitably reinvented to be interdisciplinary, can fit this profile because their other 'product line,' besides research, is people. When research and learning are combined, far greater risks can be taken."[35]

Linking learning and research has great potential to continue innovative thinking and technology development. Perhaps this is why Merrill J. Bateman, former president of Brigham Young University, promoted the concept of "student mentored learning" in which he wanted all undergraduates, at some time in their education, to be involved in research, development, and publication with faculty—linking learning and research.[36]

As we consider the exponential growth of technological knowledge in agriculture since 1830, it is interesting to note Elder Joseph Fielding Smith's perspectives on the discussion of the "waters and the land" (D&C 61:14–17). Elder Smith provided the following insights:

> In the beginning the Lord blessed the waters and cursed the land, but in these last days this was reversed, the land was to be blessed and the waters to be cursed. A little reflection will bear witness to the truth of this declaration. In the early millenniums of this earth's history, men did not understand the composition of the soils, and how they needed building up when crops were taken from them. The facilities at the command of the people were primitive and limited, acreage under cultivation was limited, famines were prevalent and the luxuries which we have today were not obtainable. Some one may rise up and say that the soil in those days was just as productive as now, and this may be the case. It is not a matter of dispute, but the manner of cultivation did not lend itself to the abundant production which we are receiving today. It matters not what the causes were, in those early days of world history, there could not be the production, nor the varieties of fruits coming from the earth and the Lord can very properly speak of this as a curse, or the lack of blessing, on the land.[37]

The knowledge explosion since 1800, as noted above, came in part as a result of research and practical education. The "lack of blessing" noted by Elder Smith and the blessing on the land in these last days as noted in Doctrine and Covenants 61:17 support the notion that the dispensation of the fulness of times will be a time when all truth is revealed, both spiritual and temporal. The knowledge of the soils and the efficient means for cultivation has, in great measure, come as a result of agricultural research at land grant universities. It is also interesting to note that Brigham Young University has been organized on a programmatic model similar to the land grant universities.

Communication Technology

Technological advances in communication technology since the early 1800s are astounding. The demands of the early industrial revolution for improved and speedier methods of communication were insatiable. The need for faster, more accurate means for communication in the early 1800s was evident given that Andrew Jackson fought the battle of New Orleans against the British two weeks after the truce had been signed—the word that the war had ended did not reach him until after the battle was fought and won.

Print communication. The main means for communication in the early 1800s were books, newspapers, and letters. Printing presses at this time were slow and cumbersome to operate. In fact, the printing presses used by Benjamin Franklin in the mid- to late-1700s differed very little from the press developed by Gutenberg in the 1400s. Given the extensive time required to print documents (it would take about ten hours of press time to print one thousand copies of a short newspaper), and given that weeks or months would pass before the news arrived, newspapers of this time period seldom included current news.

In the United States there were approximately 150 newspapers in 1800, in 1830 there were 863 newspapers, and there were more than 2,800 newspapers by 1850.[38] The rapid growth in the number of newspapers came as the result of a country that provided for a free press and significant technological developments in printing technology. One of the greatest improvements in printing was the development of the cylinder press, initially developed in Britain and used to print the *London Times* as early as 1814.[39] The cylinder press was improved by Robert Hoe, an American whose presses, known as "Lightning" presses, were capable of printing more than 8,000 papers an hour by the 1840s. By the 1860s newspapers in all the larger cities had installed Lightning presses.

Advances in printing technology increased demand for high-quality, low-cost paper. The process of manufacturing paper from wood pulp by machine was developed in the early 1800s. Technological improvements in paper manufacturing were embraced in the United States, especially given the access to significant pulp resources. By 1830 the United States was the greatest paper-producing nation in the world.[40] Likewise, advances in printing inks paralleled the advances in printing press technology and paper manufacturing technology.

From the mid-1800s until the 1980s there were several significant technological advances in printing, including linotype, offset lithography, halftone photography, four color rotogravure, and web-fed presses, to name a few. These technological advances improved quality, speed, and accuracy of print media while significantly reducing costs.

However, the advent of digital electronic and computer technology in the 1980s has had an astounding impact on print communication technologies. The digital age has provided technologies that have rendered many of the former printing technologies obsolete. For example, color separation once was a laborious, costly process using film cameras. Today, color separation is handled almost automatically by specialized computer software. Using film to make offset printing plates has been replaced by making printing plates directly from electronic computer files. And digital photography, with easy electronic manipulation, has all but rendered film photography obsolete in the print media arena.

Even with the advances in print technology, some have intimated that we are heading to a paperless society—one where print media using paper will be replaced entirely by electronic media. The future paperless society would provide print documents via CDs, DVDs, the Internet, and so forth. Perhaps these astounding technological innovations will lead to the elimination of written documents, given that electronic media can deliver video and voice with ease.

Electronic communication. Basic knowledge of electricity, batteries, and electromagnetism provided the enabling elements for the development of electronic communication in the early 1800s. While many inventors were working to develop the telegraph, it was not until Samuel F. B. Morse developed a plan for transmitting letters (commonly referred to as the Morse Code), and hence words, via electromagnetic devices that the telegraph became practical. With federal funding, Morse was able to demonstrate telegraphy in 1844 by sending messages from Washington DC to Baltimore. This demonstration led to rapid adoption of the telegraph in large cities in the eastern states. The telegraph significantly increased the speed at which messages and the news could be sent across great distances. For example, in December of 1848 President James K. Polk's message to Congress was carried by wire to St. Louis, where it appeared in print within twenty-four hours.[41]

Within a few years the railroads realized that the telegraph was a natural companion to their efforts. Railroads began to install telegraph lines along their rights-of-way. In 1856 the Western Union Telegraph Company was founded.

The idea of a trans-Atlantic telegraph cable had great promise for speeding communication between the United States and Europe. Consequently, the U.S. Congress passed an act in 1857 authorizing the president to negotiate with England to jointly lay telegraph cable across the Atlantic Ocean. The project was undertaken, and Queen Victoria cabled greetings to President James Buchanan across the Atlantic on August 16, 1858. This first attempt, however, soon proved futile as the cable weakened in a few months and eventually failed. Neither England nor the United States were willing to attempt laying another cable until after the U.S. Civil War. In 1866, and again in 1868, two new cables were laid across the Atlantic. For the remainder of the nineteenth century, telegraph was the major technology used to communicate across the Atlantic Ocean.[42]

During this same time, intercity telegraph systems expanded in the United States, becoming a key technology for communication. While the telegraph was becoming an indispensable communication tool, there was need for a more personal, one-on-one communication system. Alexander Graham Bell began experimenting with a device that would transmit the actual sound of a human voice. The result of his work was the telephone, which used electromagnetics and membranes to transmit the sound of a voice. In 1876 Bell was granted the patent for the telephone, which led to the organization of the first telephone company.

The use of the telephone expanded as telephone exchanges and switchboards were developed. Near the turn of the century, President McKinley was the first U.S. president to make extensive use of the telephone. It was during President Taft's term in office that a phone exchange was installed in the White House. Businesses and newspapers quickly realized that the telephone was critical to their operations. However, unlike the telegraph, the telephone was a technology that was used directly by the people.[43]

The telegraph and the telephone both required that miles and miles of wire be strung. A downside to using wire for electronic communication is that when the wire breaks or is cut, the communication ends. Hence, many scientists were experimenting with "wireless" communication in the late 1800s. James Clerk Maxwell, a British physicist, developed the theory of electromagnetic waves.[44] Heinrich Hertz, a German, demonstrated that electromagnetic waves could be sent through space at the speed of light.[45] Building on these discoveries, Guglielmo Marconi developed a practical use for them known as the wireless telegraph. Marconi patented his device in England in 1897 and founded the Wireless Telegraph Company. His radio telegraph used a Morse telegraph key to break the circuit and send messages using Morse Code. He established the Marconi Wireless Telegraph Company in the United States in 1899.[46]

While the wireless telegraph had great potential, it is interesting to note that wireless was quickly adopted by passenger ships as a safety device. Disasters such as the sinking of the *Republic* in 1910 and the *Titanic* in 1912 led to enactment of federal laws requiring all U.S. ships carrying more than fifty passengers and traveling more than two hundred miles to have a wireless telegraph and skilled operator on board.[47] Wireless telegraphs were also determined to be extremely valuable in military settings.

In the early 1900s several inventors were investigating the idea of transmitting voice via wireless. Obviously, transmitting voice and music required more sophisticated technologies than those required to transmit dots and dashes of Morse Code. Significantly more power would be required to transmit voice. The development of large alternators, or dynamos, and of tube amplification, magnetic amplifiers, and so forth led to radio as a practical means for communication.

Public radio broadcasting began in Pittsburgh, Pennsylvania, in 1920. The Westinghouse Company erected a powerful radio transmitter and began broadcasting over station KDKA. Additional radio stations emerged in other locations. Sponsors were used to help cover the costs for broadcasting, and the public generally accepted "commercials" as part of the various broadcasts.[48]

President Heber J. Grant participated in the first radio broadcast in Salt Lake City over station KZN. Shortly thereafter The Church of Jesus Christ of Latter-day Saints purchased the radio station and changed the call letters to KSL.[49] Radio was used to broadcast general conference to overflow crowds in 1923. Within a few years it was estimated that more than fifty thousand people were listening to general confernece via radio.[50] In 1929 the Mormon Tabernacle Choir began its weekly radio broadcasts, the longest continuously operating radio program in the world.[51]

The concept of broadcasting pictures, or television, began much like radio, in research labs. Developments in mechanical scanning of images were improved when Philo T. Farnsworth invented an electronic scanner, which he patented in 1927.[52] Several developments in television were made in the 1930s. At the New York World's Fair in 1939, television was introduced as a service to the public by RCA and the National Broadcasting Company (NBC). The advent of World War II halted expansion of television technologies, but shortly after the war ended the public wanted television sets in their homes. The expansion of the number of television broadcasting stations and the number of homes having TVs was astounding.

All forms of electronic communication have limitations. To instantly communicate from one side of the world to the other requires wires as the curvature of earth negated the use of line-of-sight wireless technologies. International broadcasts were either delayed or transmitted via wires until the developments in satellite technology were made. The first communication satellite, Telstar, developed by Bell Labs, was launched in 1962 and allowed for instantaneous wireless communication between Europe and the United States.[53] With satellites, wireless transmissions are in effect broadcast to a satellite and retransmitted to other parts of the earth. The Church began installing satellite dishes at stake centers in the 1980s to broadcast general conference and targeted firesides and training throughout the world.

The development of the Internet, from its military roots to its worldwide impact today, is astounding. Internet technologies use physical connections, with wire or optic cable or both, and wireless connections. The market penetration in the United States and throughout the world has made significant impacts on how people communicate, work, shop, plan travel, and so forth. Again, the Church has adapted Internet technologies to disseminate general conference, firesides, and training sessions throughout the world. The Church also uses the Internet to effectively communicate information on its Web site and to revolutionize genealogical research with its online database.

Developments in Transportation Technology

In the early 1800s the transportation of people and goods was limited to water or land travel. Water travel included an array of types of boats and ships designed for everything from ocean voyages to river navigation. Given that the New World had few roads, rivers served as the first highways in America. As a result, early settlements were located near rivers and oceans.

Land travel was limited to walking or using animal power, either directly (by riding a horse) or indirectly by pulling a carriage, wagon, or sleigh. Of course, with relatively few roads and bridges in America, land travel often required water travel (for instance, in ferryboats) as an enabling technology. Development of road-building equipment such as Blake's stone crusher[54] and the scraper improved road construction.

Land travel soon included railroads. In the beginning, railroads used various power sources, including horse-drawn cars, sailing cars, and steam-engine-powered cars. Steam engines won out as the best technology. In the early 1800s steam engines were imported to the United States from England. Later, American industrialists would improve on the British engine technology, and steam engines would be manufactured in the United States. Railroads quickly became a key transportation technology, moving both people and goods, and the mail and the news from point to point. The use of railroads to move troops and supplies during the U.S. Civil War was critical to the war effort for both sides. In addition, the expansion of railroads led to the establishment of standard time zones. The U.S.

transcontinental railroad was completed in 1869. It was fitting that Brigham Young was on hand at Promontory Point when the last spike was driven to complete the U.S. transcontinental railroad. Now Latter-day Saint converts could come to Utah on the railroad, in relative ease, avoiding the long, arduous, and hazardous overland trek.

Water transportation in the early 1800s included the construction of canals. The Erie Canal, connecting Lake Erie with the Hudson River, was the first great American canal. Before its construction, transporting one ton of freight from New York City to Buffalo cost about one hundred dollars and took twenty days. After the Erie Canal was completed in 1825, the cost dropped to five dollars per ton and took only eight days.[55] Canals were built throughout the United States. They were slow, however, and dependent on weather conditions, and so they were eventually put out of business by the railroads.

Boats and ships were powered by wind, humans, or animals until Fulton and others developed steam-powered boats. The early developers of steamboats saw great economic potential for their inventions on the inland rivers. Steamboats used a steam engine to power paddle wheels, either one at the stern of the boat or two on the sides. A key design element of steamboats built for inland rivers was a flat hull that could travel in shallow water.[56] With steam-powered riverboats, America's rivers truly became a strategic component in the transportation system. Given this, it is no wonder that Joseph Smith founded Nauvoo on the Mississippi River, as it provided a location that was easy to access in the 1840s. It is also interesting to note that the first extension of the gospel into a foreign country followed the waterways into upper Canada in the early 1830s.[57]

Oceangoing ships underwent many technological changes in the 1800s: from sailing ships, like the fast clipper ships, to steam-powered oceangoing ships; then from ships built of wood to ships built of iron; then from ships built of iron to ships built of steel. These advances increased size, speed, and safety.

Oceangoing steam-powered ships had several problems that needed to be solved. First, paddle wheels did not work well on rough seas. As a result, the screw propeller was adapted to ships from the early 1840s onward. Second, steam-powered ships had challenges stocking sufficient fuel, which reduced the amount of cargo they could carry. Third, lubrication of moving parts was difficult using animal oils, which would become rancid. Each of these challenges was overcome with newer technologies, such as petroleum refining and diesel engines.[58]

By 1900 the railroads held first place in the U.S. transportation system. Trains were safe, fast, and reliable, and the tracks stretched throughout the nation. However, the invention of the internal combustion engine in the late 1800s and its use in horseless carriages would soon render the automobile as a key component in the transportation system. Internal combustion engines were developed in Europe, and autos were being manufactured there prior to 1890. Shortly thereafter autos were being developed in the United States.

Automobile manufacturing grew rapidly in the United States. As demand for automobiles increased, manufacturers developed new techniques to meet the demand. The best known is Henry Ford's mass production assembly line. The assembly line allowed Ford to increase production significantly and to lower prices.[59]

The demand for autos also had impacts on the road and highway system in the United States. More and better roads were needed. Given the national need for highways, the U.S. Congress passed a bill in 1916 to provide federal assistance for road construction. President Woodrow Wilson was planning to veto the bill because he felt that the Constitution did not give the federal government the authority to assist in road construction. However, a German submarine appeared in Baltimore Harbor the day he was to veto the bill and, as a result, he determined that the bill could be included in the national defense act and therefore approved it.[60] The current U.S. interstate highway system, conceptualized and authorized during the Eisenhower administration, was clearly for defense purposes. Eisenhower saw the strategic advantage the German autobahn provided to Hitler's army in terms of logistics and supply, and he strongly believed that the U.S. needed a similar highway system for defense purposes.[61] The interstate highway system has provided significant benefits to American society beyond its original purposes.

Like railroads, autos were initially designed to carry passengers. Auto manufacturers also realized that there was profit in transporting freight. Hence, trucks were developed and the trucking industry was born.

Transportation technologies have not been limited to land and water systems—airplanes were developed in the early 1900s and ushered in an era of air travel. In 1903 the Wright brothers were the first to fly a heavier-than-air craft and land it safely. Advances in aviation came quickly, and the airplane saw service in World War I. Airplanes were soon used to deliver the mail and to carry passengers and freight. Larger commercial airplanes were designed and airlines organized. World War II brought greater improvements in aviation, with the jet plane being developed near the end of the war. Jet, or turbine, engines provided significant increase in power, which led to the development of large passenger airplanes.[62] Today, air travel is integral to our transportation system.

The ease of travel within and between continents is a marvel of the modern age and is critical to the administration of The Church of Jesus Christ of Latter-day Saints. General Authorities travel weekly to stake conferences throughout the world in order to share messages and train local leaders. Air travel also allows thousands of missionaries to travel with ease to their fields of labor.

Reflections on Technology Development

Reflecting on the advances since the early 1800s, it is easy to see the cumulative nature of technology. Improvements in devices, machines, techniques, materials, systems, and so forth build on earlier developments. In most instances, related technologies had to be discovered or developed in order for new breakthroughs to take hold. The related technologies are often referred to as enabling technologies. For example, petroleum drilling and refining technologies had to be developed in order for the development of the internal combustion engine, and thus automobiles, to become practical.

The cumulative nature of technology since the early 1800s has also enabled some organizations to flourish, and perhaps others to decline. For example, The Church of Jesus Christ of Latter-day Saints has utilized advances in communication and transportation technology to establish a worldwide presence. After establishing its headquarters in Utah, the Church encouraged members to gather. This often required great sacrifices as wagon and handcart travel across the plains and mountains was difficult and hazardous. Once the transcontinental railroad was completed, members traveled to Utah on the train.

In terms of maintaining communication with members worldwide, the Church has embraced satellite and internet technologies. Church General Authorities travel weekly to the corners of the earth to meet with members in stake and regional conferences. Using air travel, this is relatively easy to do compared with the travel of the Apostles in the first century, or even those for the first hundred years of this dispensation.

Global Impacts of Technology

There is no doubt that technology has changed the institutions of society or that the rate of change is accelerating. Elder L. Tom Perry stated that "as technology sweeps through every facet of life, changes are occurring so rapidly that it can be difficult for us to keep our lives in balance."[63] Individuals and families are being impacted as a result of technology and technological changes. Kranzberg noted that "technology is neither good nor bad; nor is it neutral."[64] It must also be understood that technology is like a two-edged sword—it cuts both ways. That is, technology has both positive and negative effects on people, the environment, the economy, governments, and so forth. Latter-day Saints and the world at large need to be particularly cognizant of the power of modern information technology for the communication of both good and evil.

As noted earlier by Postman, technology brings pervasive and systemic change. The impact of technology on society and the environment may be immediate and intended. However, the impact of technology may also be delayed, indirect, and unintended. Thus there are no perfect technological solutions.

Summary

In summary, technology and the Lord's work are inseparably linked as noted by President Hinckley when the familysearch.org site was launched. He stated, "The Lord has inspired skilled men and women in developing new technologies which we can use to our great advantage in moving forward this sacred work."[65] Religion provides a human value structure for developing and deploying appropriate technologies. Technology provides the means for communicating the good news of religion to the inhabitants of the world and to improve the efficiency and effectiveness of the operation of the Church. The challenge we face is to determine how and where best to use technology to further the work.

Notes

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6. J. H. Gibbons, *Technology Education: The New Basic*, videocassette (Albany, NY: Delmar, 1988).

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10. *Encarta World English Dictionary*, s.v. "science."

11. See Rustum Roy, "The Relationship of Technology to Science and the Teaching of Technology," *Journal of Technology Education* 1, no. 2 (1990): 10.

12. Roy, "Relationship of Technology to Science," 7.

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20. Faust, "Of Seeds and Soils," 48.

21. See Preston Nibley, *Brigham Young: The Man and His Work*, 4th ed. (Salt Lake City: Deseret Book, 1960), 406.

22. George Albert Smith, *Sharing the Gospel with Others*, comp. Preston Nibley (Salt Lake City: Deseret Book, 1948), 40–41.

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27. See Jim Platts, *Meaningful Manufacturing* (York, UK: William Sessions, 2003), 19.

28. Platts, *Meaningful Manufacturing*, 18.

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40. See Oliver, *History of American Technology*, 211.

41. See Oliver, *History of American Technology*, 219.

42. See Oliver, *History of American Technology*, 434.

43. See Oliver, *History of American Technology*, 439.

44. See Oliver, *History of American Technology*, 496.

45. See Oliver, *History of American Technology*, 496–97.

46. See Oliver, *History of American Technology*, 497.

47. See Oliver, *History of American Technology*, 497.

48. See Oliver, *History of American Technology*, 498.

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50. See Lloyd D. Newell, "Richard L. Evans, A Light to the World," in *Out of Obscurity*, 268.

51. See Cowan, "Latter-day Saint Century," 18.

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53. See Oliver, *History of American Technology*, 545.

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58. See Oliver, *History of American Technology*, 192.

59. See Oliver, *History of American Technology*, 195.

60. See Oliver, *History of American Technology*, 482.

61. See Richard F. Weingroff, "The Man Who Changed America, Part II," *Public Roads* 66, no. 6, http://www.tfhrc.gov/pubrds/03may/05.htm.

62. See Oliver, *History of American Technology*, 486.

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