

An Introduction to the Early Years of the Electrification of Warfare Communications

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The electrification of warfare communications happened through tinkering alongside uneven developments from formal scientific experimentation. This included the creation of new scientific theory, the invention, implementation and refinements of new technology, increased capability for mass scale precision manufacturing and the integration of the new technology into experimental military use and doctrine. Civilian uses of electrical communication were concomitant and allied. That being said, the main focus of this paper is the interrelation of the development of science, the history of how elementary electrical knowledge emerged, how this electrical knowledge was applied to communications and how electrical communications technology changed warfare.

The history of the electrification of warfare communications was linked with the larger history of science and its protocols. Scientific knowledge of electricity became increasingly quantified, comprehensive, distilled and generalized. By the middle of the 19th century, the understanding of the relationship between electricity and magnetism made possible the beginnings of electrical communications applications, the first being the telegraph. This paper presents many of the steps of discovery, invention and implementations in the electrification of communications story during its first dozen decades, from the late 18th century to the end of World War I. The process has continued and is ongoing.

The gradual electrification of warfare communications has been one of the most important changes in warfare, if not the most important change in the last two centuries. Its comprehensive, substantial and consequential story has only been told in snippets and paragraphs, or works with other orientations. This historical omission is herein, briefly, remedied by

collecting, reorganizing and refocusing available information into a more cohesive whole. This article is an overview of that more cohesive whole.

With the electrification of warfare communications, information gathering, analysis and command and control became more rapid over greater distances. Initially, the changes were far from technologically perfect and not integrated. One major problem, “latency,” the modern telecommunications term meaning the lag between the gathering and transmission of information and the reception and implementation of that analyzed information, was gradually reduced. The problem of latency, present with line-of-sight communications, was lessened through electrification, first, by wire communications and later by wireless. The technology gradually came to provide improved detection of an enemy presence or movement through electrical sound gathering on the surface, in the air, and under the seas.

During the 19th and very early 20th centuries, electrical telegraphy, telephony and wireless communications were sequentially developed. Their durability, military effectiveness and integration with other systems continuously improved. It was a trial and error process, with many trials and many errors. Each new technology had its energy, storage, transmission requirements and problems. The continuing goal was through the application and integration of new technology, to increase the quantity of gathered information, to decrease the analysis time and to more rapidly disseminate actionable information and commands to battlefields. The existence of new electrical communications technology did not immediately translate into increased military effectiveness. This would take the establishment within the military, of a new cultural commitment of acceptance, adoption and actual utilization. It also took expertise, revised protocols, training, an interest and willingness (if not enthusiasm of commanders) to embrace these new technologies. Thereafter, companies were able to develop large scale civilian-based, precision, industrial capacities to produce the new hardware. Each new stage of change required the building of a critical mass of multi-level commitment. Confidence was gained through risk taking, training and experience. Like the development of electrical theory and applied technology, the military implementations were uneven.

The electrification of warfare communications began with the use of electrical telegraphy during the Crimean War in the 1850s. Alexander Graham Bell's patent for the telephone was filed on February 14, 1876. The patent was too late for telephone systems to be used in the Franco-Prussian War of 1870, but was well established by the end of the century. The last of the three great inventions, Marconi's wireless communication, was operational between North America and Britain by December 1901 and was used between ships in the Russo-Japanese War of 1905. All three types of electrical communication were used during the Great War of 1914-1918 for conveying collected intelligence, for command and control and reporting war news among battle theatres as well as to the home front. There was an increased awareness of the need for security when using these three systems. Codes were used first. Electronic voice scrambling was developed for telephone use by the end of World War I.

At the same time that warfare communications were being electrified, other uses of electricity were being developed and adopted by the military. Two types of motive engines contained electrical components: internal combustion engines with magnetos or sparkplugs and electric engines with electromagnets. These powered land vehicles, airplanes and submerged submarines. American Dodge and Cadillac automobiles used in the First World War gained electric starters. Incandescent bulbs for automobile lights, search lights, camp lights, naval beacons, spotlights, lanterns and flashlights, fueled by batteries or generators, gradually replaced candles and chemical lanterns. Sound detection technology was being developed for use on land, in the air and under water. X-ray diagnostic units powered by electricity helped medical professionals by providing images of war venue injuries. The leaders who recognized the multitude of potentials for the electrification of warfare benefitted from the advantages offered by improvements in the new technology. Electrical communication was but one of these many uses for the new power source.

Tinkering and Science: The Essential Processes for Developing an Understanding of Electricity

Tinkering and science were both vital in generating an understanding of electricity and its applications. Sometimes knowledge gained by observations of natural phenomenon, tinkering, or by scientific experimentation and theory building was shared; sometimes it was not. Missed opportunities have been recognized only in hindsight. There is no single definitive definition of science.

Correspondingly, there was no definite beginning of science. Science has always had key attributes: a desire to rationally understand the natural world, to investigate, experiment, measure, analyze, attempt generalization and to extrapolate. Science seeks evidenced knowledge. It has produced a body of substantiated knowledge that has replaced myths or false beliefs. As in the case of Galileo Galilei, the challenges to existing beliefs have often been viewed as threatening to existing institutions or power elite, or simply to those resistant to new ideas. Science has led to truth, understanding, technological advances, and usable applications. It has important humanistic limitations. It does not generally attempt to deal with ponderings such as divine relations, ethics, or the philosophical.

Science has continually evolved, with gradually enlarged scope and refined protocols. From Archimedes' discoveries and classification of basic machines, experimentation has been a key component. Mind experiments about large and small scale views of the natural universe have also been important. Albert Einstein, using mind experiments, developed his special and general relativity theories in the early 20th century that enlarged Sir Isaac Newton's views of gravity, space, and time. Quantum mechanics has contributed to the small scale, probabilistic understanding of the atomic level of the natural world. Mind experiments eventually have needed physical confirmation. Increasingly precise observation and detection technology have aided in providing these confirmations.

Quantification through increasingly powerful mathematics has supported scientific theories. Early in the development of modern science, Galileo describe his inventions and findings quantitatively. David Wootton, in *The Invention of Science - A New History of the Scientific Revolution*, quoted Galileo's *The Assayer* (1623), which emphasized that quantification through

mathematics has been more than a buttress to science. It has been the necessary language in describing the universe. Using geometry, algebra, and primitive calculus Sir Isaac's Newton's theory of gravity was a masterwork in scientific thought described in quantitative terms. In the field of electricity, James Maxwell's equations concerning the relationship between electricity and magnetism, produced in the mid-19th century, were the essential underpinnings for the electrification of communications. The mid-19th century telegraph harnessed electrical power using an operator's key to close a circuit which produced a transmittable electric impulse.

Cognitive leaps, hypotheses, tinkering, mind experiments and physical experiments, were all blended to formalize a new, base quantified electrical theory that would continue to develop. Like many, if not most scientific theories, electrical theory developed with leaps to clarity and periods of lesser growth of understanding. The desired need for survival in times of warfare has, reallocated research priorities and resources and has promoted scientific discoveries. Science, even before it was a named discipline, has been the search for truth about the natural world through observation, investigation, experimentation, data collection and organization, analysis and reflection. In the epistemology of science, hypotheses, or informed guesses have been the starting points. Repeated experimentation to either confirm or reject hypotheses have resulted in generalized theories and eventually, fewer scientific laws. Great changes in perspective, have been revolutionary, but scientific protocols and the all-important details, have been developed evolutionarily, incrementally.

The widespread electrification of warfare communications would not have been possible without systematic scientific investigations that were communicated among the growing body of experimenters and theory developers. Financial able passionate individuals, the private sector of state economies, state governments and international research centers have advanced scientific knowledge. Scientists generally shared their results and theories through demonstrations at learned societies and through publications Sometimes, these results and theories have been for a time, held secret for refinement that would lead to patent applications, security and

military applications. Scientific knowledge has eventually been more widely disseminated. There have been false leads, miscalculations, invalid interpretations, and experimental failures. Failure has been a necessary part of the acquisition of scientific knowledge.

Sometimes, important knowledge has been lost and then rediscovered. While scientific knowledge has expanded, the basic properties of the natural universe seem to be constant. For warfare, pure hypothesis testing and theory formulation concerning electricity has led to military applications of hardware in the battlefield. These applications often lagged behind the initial inventions. Hardware breakthroughs required subsequent systemic integration. The successful integration of theory development, hardware invention and implementation of electricity-based warfare communications has been dependent on field testing alongside and the wisdom, creativity and commitment of political and military decision makers and leaders. The full implementation of new hardware and systems has been an uneven process, not consistently or continuously sequential.

The Baghdad Battery - Electrical Knowledge Found and Lost

On March 13, 2019, this writer observed two replicas of the Baghdad Battery at the Berkshire Museum in Pittsfield, Massachusetts. Quite possibly, some early tinkerer/inventor had not only realized a potential application for electricity, but had developed a means to generate it chemically to produce an even flow of low voltage current. The label on the display in the Berkshire Museum read as follows:

William F. C. Gray, working at the GE High Voltage Lab in Pittsfield, reproduced the jar and tested it with electrolytes like grape juice. He was able to produce about 2v (volts) of electricity, proving that the discovery may have been used for that purpose. However, there are no surviving primary source documents regarding who created the battery or if it was even a battery. In 1938, German archeologist Wilhelm Konig found or acquired access to an earthenware jar which was allegedly discovered at Khujut Rabu, a site close to Bagdad. The jar had a stopper at the top composed of an asphalt-like material. Along with the jar were found an iron rod and a copper pipe or cylinder. The three components were found separately, but

assumed to be parts of the complete unit. The jar's use and age were not identified, but the construction was similar to Alessandro Volta's battery which was invented, or rediscovered in 1799. There have been estimates that the earthenware jar and its accompanying internal components were from the Parthian period, between 250 BCE and 250 CE, giving rise to the jar's two titles: the Baghdad Battery or the Parthian Battery. Speculation has been made that if the discovery was a battery, it may have been used to gold plate silver items as has been done in modern times in that region. This writer has viewed many later batteries similar to the Baghdad Battery but of the Volta design in the Smithsonian Museum on the Mall in Washington, D.C.

There was no known electrical theory to support the design or purpose, of the Baghdad Battery. The archeological evidence indicates just tinkering with no apparent long-range knowledge transfer.

Electricity, Magnetism, and Induction

For millennia, humans watched the awesome power of lightning and in the absence of science created myths about this natural phenomenon. The lightning which fascinated and frightened the ancients is now theorized to be the result of the friction between molecules in clouds causing the ionization (essentially the rubbing off of electrons) of different areas which eventually discharge to bring about a sudden equalization, a charge balance. The charge differentials may be between clouds or between clouds and the ground. The areas that contain the polarizations are termed fields. By historical convention, fields which contain an excess of electrons are termed negative, and those with a deficiency of electrons are positive.

The flow of electricity has two common characteristics: voltage and amperage. The common definition of voltage is electric potential or electromotive force. Some might say it is electrical pressure. Amperage is electrical strength or power, the number of electrons passing a point in a unit of time. Your AA, AAA, or 6-volt dry cell batteries that powers household conveniences such as smoke alarms or flashlights have low voltage and low amperage direct current. A Van de Graaff belt friction generator produces high voltage (as much as 100,000 volts from a small unit), low amperage direct current that can make your hair stand on end without destroying your

nervous system. Higher voltage and amperage current, such as lightning can crack tree limbs or kill people.

Magnetism was a second physical phenomenon essential for early electrical communications technology. Magnetism is a characteristic of attraction or repulsion, mainly of ferromagnetic elements: elements or compounds such as iron, nickel, their alloys, and cobalt that exhibit magnetic fields. These elements or compounds, naturally or by intervention, have their atomic structures aligned causing fields of polarity. The naturally occurring permanent magnet, lodestone (magnetite, Fe_3O_4), used in compasses, had pointer needles directed to the earth's magnetic poles which are thought to be related to the magnetic composition of the planet's core. You probably recall from middle school science class that iron filings sprinkled on top of a permanent horseshoe or bar magnet show the magnetic fields extending beyond the magnets themselves.

Electricity and magnetism were not understood to be related until the experiments and writings of James Clerk Maxwell in the middle of the 19th century. This electro-magnetic relationship was critical in developing the hardware for electrified communications. The region around a wire on which a current is flowing on its surface has an electro-magnetic field. In the case of an electrified wire, or a coil of wire, the field extends beyond the wire itself. This projection of the electro-magnetic field is termed induction. Through induction you can charge a cell phone by setting it on a charging station without directly connecting the two, and the static electricity in your body can sometimes activate an elevator call button without actually touching it. You may recall in elementary school rubbing your feet on a carpet producing a buildup of electrostatic charge on your body and then holding your pointer finger near, but not touching, a classmate's ear. The discharge had sufficient electrical voltage (electrical pressure) to cause a visual and audible spark. But, having low amperage (electrical power, the number of electrons passing a point in a unit of time), the intended victim's ear was not dismembered, or even burned. Through alternating the direction of current flow, electro-magnetic energy can be, through attraction and repulsion, changed into motion in an electric motor. Impulsed, even coded, electric energy can be

transmitted along wires for communication. If the electro-magnetic energy is powerful enough and directed, it can travel great distances without the aid of a conducting media, such as a wire.

The first transmissions of electrical communications, telegraph and then telephone, used wires as a conducting media. The power of the electrical signals weakened with distance because of the dissipation of energy during transmission. Methods of signal amplification or repetition were needed. Wireless forms, like lightning, made use of the projection of electro-magnetic energy without a conducting media. Wireless communication can operate in a vacuum. If operating in a charged atmosphere wireless signals can be diminished, distorted, or squelched.

The First Essential Problems: Producing, Storing, Modifying, and Transmitting Electricity

The evolution of the understandings about electricity, magnetism, and induction, their interrelationships, and their initial applications to civilian and military communications were accomplished during the first half of the 19th century. During the second half of the century through World War I, the progress continued. There were four basic problems to solve: 1.) Creating a regular, sustainable source of usable electricity, 2.) Storing the created electricity. 3.) Controlling, modifying and regulating the voltage, amperage and the type of electro-magnetic energy. 4.) Applying the created and stored electro-magnetic energy to the transmission of information over great distances.

Capturing lightening in Leyden jars or by rubbing felt on glass did not produce sustained sources of power with regular intensity. Chemical batteries and generators were required. Battlefields needed portable batteries for short range communications and generators for longer range signal origination and reception. Transmission required sufficiently regulated power, the means to send and receive electro- magnetic signals and systems to repeat or boost declining signal strength over distance. Initially, there were two wire

transmissions methods: telegraph followed by telephone. Then, in the 1890s came wireless: ground-based wireless, ground-to-ship wireless, ship-to-ship wireless, air-to-ground and ground- to-air wireless. By World War I, wireless communications were possible to surfaced submarines. Electrical communications to and from early tanks were attempted but not successful because of high noise levels in tanks, insufficient power sources and inadequate aerials.

Military Adaptation of Science Based Technology

There has sometimes been a lag between the initial invention of new, potentially useful hardware and tactical, strategic battlefield implementations. This was the case with military applications of electricity-based communications. The telegraph, telephone and wireless all saw greater civilian use prior to military adaption. There have been two main reasons for this. First, new technology needed to be integrated with other existing systems. This required planning, trial and error field-testing, correction of systemic deficiencies, re-testing, subsequent training and finally battlefield utilization. Armies cost a lot. Funding for new technology and new systems meant increased costs.

Second, mindsets or paradigms based on visions and views of past battlefield situations, older formal protocols, and the scope of established training had created long standing military traditions. The lack of foresight, wisdom, creativity and commitment of military leaders and political decision makers have exacerbated the adoption lag time. Military personnel need to take battlefield risks while following orders. Seeking early adoption of new scientific hardware and creating new systems may not have been part of basic leadership training in the 19th and early 20th centuries. An example of this lack of early military adoption, leadership and usage was the reluctance of Russian Vice Admiral Zinovy Rozhdestvensky to use wireless in the Battle of Tsushima in 1905, fearing Japanese detection of his attacking fleet. Shore-based observations of the approaching Russians were transmitted to Japanese Rear Admiral Togo Masamichi via wireless and radio directed Japanese ships won the battle. Despite the noted limitations, scientific understandings did

produce new electricity-based communications that were successfully used by the military. President Lincoln's growing mastery of the telegraph during the American Civil War of 1861-1865 to first monitor war news and then direct strategic plans to battlefronts was a classic example of rapid adoption and systemic integration of electrical communications to warfare. On many fronts, the history of the science of electricity, civilian inventions, and the military adoptions of the resulting hardware were intertwined.

The Beginnings: Electricity in the 18th Century

The bright flashes and destructive power of lightning and the magnetic effects of lodestones were two observable natural phenomena of electro-magnetic energy during the 18th century. The static electricity caused by rubbing amber caused English investigator William Gilbert (1544-1603) to name the effect "electrical effluvia" from a Latin term referring to its origin as amber.¹ The Leyden jar was independently invented in the mid-1740s by German Ewald Georg von Kleist and by a Dutch physics professor at the University of Leiden, Pieter van Musschenbroek. The Leyden jar was named after the workplace of the latter. The jar did not produce electricity, but stored it. The jar, which was at the end of Benjamin Franklin's kite string (during his now famous experiment), was a glass bottle which contained alcohol or water in the bottom and was topped by a nail or metal chain. It was meant to temporarily store high voltage, lower amperage electricity produced by a friction machine. It was not intended to store high amperage lightning strikes. Franklin was lucky not to have had a shorter and more limited career.

The Early 19th Century: Producing Electricity Chemically and the First Telegraphs A major breakthrough came in 1799 when Italian chemist and physicist, Alessandro Volta, produced his Voltaic pile which chemically generated an electric current. With alternating zinc and copper plates submerged in an electrolyte solution of saltwater brine or sulfuric acid, the Voltaic pile produced the desired steady flow of electricity with the zinc electrode being the negative pole and the copper electrode being positive. The

¹ Jill Jonnes, *Empires of Light: Edison, Tesla, Westinghouse, and the Race to Electrify the World*. (New York: Random House Trade Paperbacks, 2003): 18-20, 23.

copper was eventually lost over time due to the chemical reaction and the battery ceased to function until replacement copper was installed. The zinc plates became coated, though the zinc was not part of the reaction. The stronger sulfuric acid electrolyte, being a liquid, made this type of battery more dangerous to transport. It was a prelude to dry cells which could be used safely in battlefield situations. Emperor Napoleon, ever searching for usable technologic military applications and advantages, took notice. In 1801, Napoleon invited Volta to Paris, where Volta repeated his experiments with two Voltaic piles, at the National Institute in the presence of Napoleon, who honored Volta with a gold medal and an annual income.²

Today, a primitive chemical battery or "voltaic pile," built in 1805 by Alessandro Volta and loaned by Canisius College was viewed by this writer in a display in the Smithsonian National Museum of American History in Washington, D.C. Also in the Smithsonian is an early trough battery, the Samson Battery No. 2 built in 1801 before Volta's displayed battery. The batteries are surprisingly large. The Volta battery is approximately a yard high. The layers of the pile are in a glass tube a few inches in diameter. A third battery on display is a modified Volta battery constructed by J. Frederik Daniell in England in 1836. A label on this chemical battery notes that "Modifications of the Daniell cell were widely used in American telegraphy."³ As chemical battery technology improved, the power (amperage and voltage) of the batteries likely increased making electrical telegraphy possible.

With a battery to supply steady electric current, experimentation became easier. In 1820 Hans Christian Oerstedt discovered the electromagnetic field caused by electric current.⁴ André-Marie Ampère, within two months of the recognition that flowing electric current in wires produced an electromagnetic field, was experimenting with the deflection of magnetic needles through the use of electromagnetic fields. On October 2, 1820, he proposed an electromagnetic telegraph consisting of 30 magnetic needles

² Carl Van Doren, Carl. *Benjamin Franklin*. (New York: Garden City Publishing Co., Inc., 1941): 164.

³ (Smithsonian National Museum of American History, Washington, D.C., visited July 17, 2018; information contained on display cards)

⁴ Huurdeman, *The Worldwide History of Telecommunications*, 31.

each controlled by two conductors. This elaborate device, requiring a 60-wire line between two telegraphs, was never made. In 1822 he constructed the first coil. Ampère became world famous not for this early proposal for the introduction of electrical telegraphy but for his discovery of two basic characteristics of electricity: tension (now expressed in volts) and current, in his honor expressed in amperes.⁵

The experiments were leading to the ideas of a functioning telegraph system that could be used by the military. There were a few more pieces of technology that would need to be created and as yet there was not overarching understanding of electromagnetism that could be expressed both qualitatively and quantitatively as a scientific theory. Electricity was still some kind of fluid, flowing lightning that traveled through wires, established fields and was related to magnetism. An important technological breakthrough happened in 1825 when a self-educated British physicist, William Sturgeon (1783-1850) constructed the first electromagnet. This electromagnet was horse-shoed shaped, made of iron and had a coil at each end. The two coils consisted of un-insulated copper wire wound spirally around an iron core that was covered with an insulating layer of varnish. He discovered that a current passing through both coils created a magnetic field between the two iron ends.⁶

Electromagnets were critical in the development of the telegraph, the first major technology in the electrification of warfare. In 1828, Joseph Henry, an American physicist greatly increased the strength of electromagnets by wrapping multiple layers of insulated wire around the coils of the units. He developed practical rules for the construction of electromagnets and constructed the first relay in 1835, both vital prerequisites for the construction of electromagnetic telegraph systems.⁷ A civilian or military telegraph unit was limited in signal transmission range by the electrical power in the system. By 1830, William Ritchie had transmitted electric signals a distance of 20 to 30 meters.⁸

⁵ *Ibid.*

⁶ *Ibid.*, 32.

⁷ *Ibid.*

⁸ *Ibid.*

The great breakthrough came in 1831 when Michael Faraday, another self-educated British scientist, presented the results of his experimentation to the Royal Society. Faraday had found that the movement of a magnet relative to a conducting circuit produces an electric current in the circuit. This was termed the law of electromagnetic induction. Magnetism and electricity were interrelated. Further, but without adequate scientific evidence, Faraday revealed the reciprocal nature of the laws of magnetism and predicted the existence of electromagnetic waves, a major achievement for the further development of electromagnetic applications and the development of radio transmission at the end of the nineteenth century.⁹ The scientific experimentations had produced evidence of a physical phenomenon, but a unified theory of electro-magnetism supported by the mathematical equations necessary for wide acceptance remained missing. This unified theory would have to wait briefly for the writings of James Clerk Maxwell.

In 1833, mathematician Carl Friedrich Gauss and physicist Wilhelm Eduard Weber, both professors at the University of Göttingen, made an induction transmitter consisting of a long, heavy permanent-magnetic rod (25-50 kg) around which a coil with a winding of some 1000 turns was moved up and down by hand to produce electricity. With this source of electricity, instead of a voltaic cell, the two professors established a transmitter that through the use of a polarity switch could cause left or right action in a galvanometer some distance away. Gauss even developed five different telegraph codes for the characters of the alphabet, using combinations of one to six mirror movements to the left or right. A telegraph system to send coded messages had been established.¹⁰

The creation of a working electrical telegraph, while the product of many experimenters, has been generally credited to an American artist, Samuel Finley Breeze Morse. Morse, was appointed a professor of Literature of Arts and Design at the University of the City of New York (now New York University). on October 2, 1832. The new university was not yet completed and Morse did not have a classroom or workspace. He had been tinkering

⁹ *Ibid.*

¹⁰ *Ibid.*, 50-51.

with ideas for an electrical telegraph since 1829 or 1830, making notes on its possible design. He received help from a friend, Leonhard Gale, who made the suggestion that the telegraph be powered by “a battery of voltaic piles.” On September 4, 1837, Morse and Gale sent a telegraphic message through a wire 550 meters long. The signal was sent from his new classroom.

Morse received technical and financial help from Alfred Lewis Vail and his father, Judge Stephen Vail. Morse worked to develop a coding system of five digit sequences of dots and dashes to transmit letters of the alphabet via the telegraph. The next seven years were years of development. With the permission of the Ohio Railroad which let him string wire on poles on the railroad's right-of-way, Morse and his associates established the first working telegraph system with parallel wires for two-way communication between Baltimore and Washington, D. C. On May 24, 1844, the “magnetic telegraph” was officially in operation with the first message transmitted being, "What hath God wrought!"

On April 1, 1845, the first public telegraph office was opened on Seventh Street in Washington, D. C. On May 15, 1845, Morse and others formed the Magnetic Telegraph Company with the goal of extending the Baltimore-Washington, D. C. line to New York City. Telegraph service between New York, at 120 Wall Street and Philadelphia began at the end of January 1846. As Morse had been a traveler to Europe and publications of his telegraph system were becoming known there too, telegraph systems soon were being constructed in Europe.¹¹

Along with the voltaic batteries on display at the Smithsonian there is currently a display of Morse's first working telegraph built for his classroom in 1837. It is noteworthy that the first telegraph system in the United States was built on a railroad right-of-way. The use of telegraph to help in the scheduling of regular trains, to sideline locals to allow for emergency express trains and to give notice to switching stations ahead of express trains, created a growing network of communication about transportation that was in place and being improved in the North before the Civil War. The dual system was a great advantage to expedite the movement of troops and supplies north of

¹¹ *Ibid.*, 56-62.

Washington, D.C. and as far west as Ohio. By the summer of 1846, the telegraph extended north to Boston and by December of 1847, west to St. Louis. Though fewer lines went south, there was at least limited telegraph service in Richmond, Virginia, (the future Confederate capitol) by the summer of 1847. It reached to Savannah in March of 1848 and even to New Orleans by July of 1848. Southern strategic points along the Mississippi River such as Baton Rouge, Natchez and Vicksburg were integrated in at least one of the competing systems in 1848 to late 1849.¹²

A Vision of the Telegraph for Military Communications

The idea of an integrated telegraph system for military uses had been in existence at least since 1801. Napoleon had commanded the construction of an optical telegraph system from Paris to Milan via Lyon. In 1804, in preparation for an invasion of England, Napoleon authorized Abraham Chappe to devise a means of telegraphing across the English Channel by day and night. A lantern system devised proved problematic in the fog over the English Channel. Limelight and parabolic mirrors somewhat helped. In March 1813 Napoleon ordered construction of a similar optical telegraph system as part of a withdrawal from Germany, from Metz to Mainz. The 225-km line with some 18 intermediate stations was completed within two months under Abraham Chappe's direction. During the retreat the Prussian army captured and destroyed the telegraph system.¹³

Napoleon not only envisioned a land-based and cross-channel military telegraph system, he had such optical systems built and used. Prussia realized the importance of such rapid signal transfers and established counter-measures of search and destroy. The military uses of the optical telegraph systems of Napoleon provided an experiential knowledge base for electrical telegraphy in the Crimean War and the United States Civil War. Crimean War electrical telegraphs were inadequate and the implementation of the great potential for centralized, coordinated command and control during the Civil War took more than a year for President Lincoln to discover, analyze and

¹² Huurdeman, *The Worldwide History of Telecommunications*, chart/map, figure 6.7 "The First Telegraph Lines in the United States", 64.

¹³ *Ibid.*, 34-37.

implement. After Michael Faraday's demonstrations of the electrical induction phenomenon in 1831 and Samuel Morse's subsequent invention of a working telegraph in 1832, the progression toward a working electrical telegraph system took incremental steps in the United States and Europe. The early telegraph found a limited military communications use in the Crimean War.

The Telegraph and the Crimean War

The Crimean War was a conflict of "a hodgepodge alliance of France, the Ottoman empire, Britain and the kingdom of Piedmont-Sardinia against the Russian empire."¹⁴ They feared Russian expansionist ambitions. To protect shipping lanes into the Black Sea, Britain and France sent fleets in January 1854. A major objective in curbing the perceived Russian expansionist aggression was for the British and French to conquer the Russian naval base at Sevastopol at the southwest corner of the Crimean peninsula. This became the center of the action.¹⁵

The Crimean War claimed the lives of some 21,000 British, 95,000 French, 95,000 Ottoman and 140,000 Russian soldiers, most of whom died from disease and deprivation rather than combat . . . in Sevastopol three huge cemeteries hold the graves of some 127,000 Russian Soldiers and sailors killed in the defense of the city.¹⁶ The war ended with the Treaty of Paris, which was signed on 30 March 1856. The Ottomans, while maintaining its independence and territorial integrity, were weakened by ceding to France their claim as protector of Christians living under Ottoman rule.

At the beginning of the Crimean War, it took five days for news to travel from the battlefield to London. Telegraphs had been built between European capitals prior to the war. In the early 1850s a foreign correspondent's reports were transmitted by a combination of steamship and horseback to the nearest telegraph center in Bucharest. Telegraph messages were prioritized for military use first, then news reporting.

¹⁴ Steve Roberts, "Crimean Chronicle," *Military History* 32:6 (March 2016): 32-35.

¹⁵ *Ibid.*, 32.

¹⁶ *Ibid.*

By the winter of 1854, with the French construction of a telegraph to Varna, news could be communicated in two days; and by the end of April 1855, when the British laid an underwater cable between Balaklava and Varna, it could get to London in a few hours.¹⁷ The construction of direct telegraph lines between French or British capitals and the Crimea allowed for supply requests to be made rapidly. However, the direct communications between field generals and the capitals led to competition between officers, heated disagreements, intrigues and threatened resignations. In one French command change, Emperor Napoleon III appointed General Jean-Jacques Péligrier to command the army's 1st Corps and General

Adolphe Niel to direct the operations at Sevastopol. Niel was an ambitious, though relative untried engineering officer who had come to the fore during the siege of Bomarsund but his role in the Crimea was not just to direct operations: he had a line straight to the emperor and had been ordered to report on (General)Canrobert's actions, or, as it turned out, his lack of action. Péligrier, too, had a hidden roll. This fiery veteran of the fighting in Algeria was sent out as Canrobert's understudy and he made little secret of his ambition to take over command of the French army.¹⁸

Commander François Certain Canrobert, uncertain and struggling with French tactics, was being undermined by fellow officers, who via telegraph could slant reports of the war's progress directly to the Emperor. Canrobert's lack of confidence and indecisiveness were exacerbated. The protocols for rapid transmission of slanted intelligence or reports from battlefields to the central commands in European capitals was not yet regulated by appropriate protocols. The new system of telegraph communications had evolved too rapidly.¹⁹

To illustrate how scarce telegraph service was during the Crimean War, there was some data on estimates of total electrical telegraph messages in some countries. These telegram numbers were not all military. The selected

¹⁷ Orlando Figes, *The Crimean War – A History*. (New York: Picador, A Metropolitan Book, Henry Holt and Company, 2010): 304-305.

¹⁸ Trevor Royle, *Crimea - The Great Crimean War 1854-1856*. (New York: St.Martin's Press, 2000): 334-335.

¹⁹ *Ibid.*

data might have included telegrams sent between the battlefields and the home nations. In Austria, the total number of telegrams sent in and out of the country was about 100,000 in 1851. This rose threefold to about 300,000 in 1856. In Belgium there were about 100,000 telegrams in 1853. This held constant through 1856. The data for France was higher, about 500,000, but did not get recorded until 1858.

Presumably, there was some telegraph contact between Paris and Turkey during the Crimean War. The data for Germany began in 1850 with about 40,000, but this increased to 150,000 in 1853 and to 350,000 in 1856. The data for Norway was more precise. In 1852 there were only about 1,000 telegrams. This increased to 46,000 in 1853, 102,000 in 1854, 104,000 in 1855 and an increase to 190,000 in 1856. The Norway data indicated how electrical telegraph was increasing during the war years. There was no data available for the war years for Hungary, Italy, Russia, or the United Kingdom. Switzerland, because of its central strategic geographical position developed as a hub. In 1852 it had about 300,000 telegrams. No data was available for 1850, but by 1854 127,000 message had been sent or received. This grew to 159,000 in 1855 and to 210,000 in 1856. Looking forward to 1870, Switzerland's telegram communications numbered 1,510,000.²⁰ The potential for greater home country direction of military operations throughout Europe and to more distant theatres of war was growing tremendously, but the lack of contiguous construction of telegraph lines made direct communication difficult in the early years.

Telegraph communications were limited to land operations. Calling for reallocations of naval assets as yet did not have the benefits of Marconi communications and continued to be by line-of-sight message communications or orders relayed by fast steamer.

In Napoleon's time, large armies and fleets strained to the limit the expanded economic, political, and technological resources which had permitted their creation.²¹ Napoleon had difficulties with supply, terrain, and

²⁰ B. R. Mitchell, *International Historical Statistics - Europe 1759-1993, Fourth Edition*. (London: MacMillan Reference Ltd., 1998): 750-752.

²¹ Geoffrey Parker, *The Military Revolution - Military Innovation and the Rise of the West 1500-1800*. (Cambridge: Cambridge University Press, 1996): 154

communications for large armies in Spain and Russia. Telegraph, railways, and breech-loading firearms were needed before armies larger than those favored by Napoleon could operate effectively; and it required the iron-clad steamship to challenge effectively the supremacy of the

Nelsonian ship-or-the-line.²² The Crimean War was a transitional war that began to use these newer technologies. The integration of warfare technology components was developing and therefore imperfect. During the Crimean War years the available data indicated that information transfer if not for command and control was increasing in volume and speed as infrastructure was built. The American Civil War would see both the technology and integration improve.

The Telegraph and the American Civil War - Lincoln and Greater Central Command and Control

While the Crimean War saw the rapid development of electrical telegraphy in Europe and the advent of its military applications, the American Civil War was the first large war in which the electric telegraph was used by the civilian government. The use was exercised most extensively by the elected Commander-in-Chief as well as military leaders for centralized command and control. It was also used for messaging between levels of command. The American Civil War saw the first wide scale use of field telegraphy serviced by competent electrical technicians working from highly moveable equipment wagons. In the North, many enlisted electrical telegraphy experts not only frequently repaired equipment, they tapped into enemy lines to intercept transmissions.

The telegraph greatly advanced the speed of transportation of troops and supplies by railroad. Even in the opening year of the war, President Lincoln, who had been a railroad lawyer, saw the potential for the military linkage between electrical telegraphy and railroad transportation to reposition and resupply troops. There was no shore-to-ship electrical communications but telegraph messages could be relayed to ships at ports of call. The first great land battle of the Civil War occurred on 21 July 1861 at Manassas,

²² *Ibid.*

Virginia, not far from Washington, D.C. The South earned the victory and the Northern army retreated toward Washington. Central command and control at this first battle was lacking. The North's retreat was chaotic. Electrical telegraphy did play an ancillary role in First Manassas by summoning the first of General Joseph E. Johnston's Confederate brigades from the Shenandoah to be transported via rail to Manassas Junction to meet General Irvin McDowell's Union force.²³

During the first year of his presidency, 1861, President Lincoln, a problem solver and a technological early adopter, eagerly used electric telegraphy, which he sometimes termed "lightning messages," to obtain war news from the various fronts.²⁴ By 1862, he was beginning to use the telegraph to get more precise battlefield reports and issue strong suggestions, even orders. Centralize command and control to distant sites was emerging. Plagued by poor field leadership, the early battles were frequently northern losses and commanding generals were replaced, including General George McClellan who had successfully built the Northern Army but was twice replaced as a field commander. McClellan, like Lincoln, was technologically savvy and used telegraphy communications. McClellan had much field intelligence but exhibited a timidity for the aggressive action that Lincoln sought. The Civil War lasted four years. During this time military electrical telegraphy use expanded and became more efficient in more rapidly coping with changing battlefield conditions.

The overall war strategy of the Confederacy included anticipated European supply support because of a demand for Southern cotton. The attrition of Northern civilian morale with Southern battlefield wins, possible victories in Maryland, West Virginia, and Pennsylvania and eventual Northern political capitulation would hopefully force negotiations and establish an independent Confederacy. While the South would fight bravely, the North would win by numerical military advantage, superior production,

²³ William C. Davis, and the Editors of Time-Life Books. *First Blood - Fort Sumter to Bull Run*. (Alexandria, Virginia: Time-Life Books Inc., 1983): 122

²⁴ Tom Wheeler, *Mr. Lincoln's T-Mails: How Abraham Lincoln Used the Telegraph to Win The Civil War*. (New York: HarperCollins Publishers, 2006): 2.

rapid supply to the field and most importantly for the purposes of this article, communication.

After General Ulysses S. Grant's victory at the strategic Mississippi town of Vicksburg, and General George Meade's third day victory at Gettysburg, Pennsylvania, the Confederacy was faced with a gradual decline in manpower, food, medicinal supplies and ammunition. Now elevated field leader of the North, Grant, aided by General Phillip H. Sheridan and General William Tecumseh Sherman, pursued a relentless war of attrition and eventually, total war. From the time of the Vicksburg success, Lincoln kept in almost constant telegraphic communication with Grant. Lincoln had a cot which he frequently used while living a substantial amount of his time at the telegraph center in the War Department next to the White House. The successful, relentless flanking of Lee's army at the end of the war was accomplished by railroad resupply of the Federal army. The ability to resupply and out-maneuver Lee was due to telegraphic control of railroad scheduling by such brilliant Union officers as Herman Haupt, field commander of the U.S. Military Railroads.²⁵

While telegraph and railroads provided the means to the eventual Northern victory in the Civil War, they did not provide the vision, aggressiveness, or leadership for an early victory. It has been well known that after Lee's withdrawal from Gettysburg with the massive losses of Pickett's charge on 3 July 1863, that Lincoln had commanded Union General George Meade to pursue Lee and destroy what remainder of his Rebel army. This Meade did not do. He had been replaced as head of the Union forces at Gettysburg shortly before the three-day battle. The losses to both sides had been high. It was raining, and Meade, a general who preferred consensus building as a leadership style, chose not to undertake the pursuit. American born but German by heritage, General Herman Haupt was furious. He went to Meade and urged him to pursue the Rebel army and destroy it. When he found that Meade was afraid or unwilling to undertake and pursue his advantage over Lee, Haupt jumped on a locomotive at midnight on Sunday

²⁵ Thomas Flaherty, editor-in-chief. *The Civil War: Rebels Resurgent - Fredericksburg to Chancellorsville* (Alexandria, VA: Time-Life Books Inc., 1985): 8-23.

and rushed away to Washington.²⁶ Haupt saw Lincoln, Stanton and Halleck and made his case for rapid follow-up. Meade was ordered by telegraph to move his army. He did not. Haupt returned to Gettysburg, greatly disappointed. The war might have ended in July 1863. Instead, Lee and his diminished army had successfully fled to fight for another two years. Meade was returned to Washington to serve where he was better suited. Haupt continued to run the railroads using telegraphic communications. The final costly victory would come when more visionary and aggressive generals, Grant, Sheridan, and Sherman, took charge of field operations. Grant, the overall field commander, while ruffled, tenacious and aggressive, was not a man of lengthy communications. He understood and used the telegraph extensively, but often with concise brevity, for intelligence on his enemy's locations. He wisely and diplomatically also made sure that Lincoln, always hungry for information, was apprised of field situations.

Earl J. Hess, writing about Civil War logistics, related the contrast between “the robust logistical power harnessed effectively by the Federal government in the North” and the “frustrated hopes, inefficient management, and rapid deterioration of track and rolling stock in the Confederacy.”²⁷ In January 1862, “the U.S. Congress granted the Federal army authority to seize railroads.”²⁸ The Federals established and operated the U.S. Military Railroad. The Confederacy, largely because of President Jefferson Davis' objection, did not. The Federals then used experienced civilian railroad men and telegraph personnel to efficiently run the integrated systems. It was teamwork which included private and public sector (military) efforts: “The Southern rail network could not adequately feed Confederate troops, transport them safely over long distances, or provide offensive mobility for Rebel armies.”²⁹

The magnitude of the North's superior, industrialized production capacity coupled with the integrated communications and supply system using railroads, wagon trains, pack animals, steam ships and sailing ships was

²⁶ General Herman Haupt, *Moving the Union Army: Reminiscences of General Herman Haupt*. (Middletown, Delaware: Big Byte Books, 2014) (Originally published 1901), 23.

²⁷ Earl J. Hess, *Civil War Logistics - A Study of Military Transportation*. (Baton Rouge: Louisiana State University Press, 2017): 97.

²⁸ *Ibid.*

²⁹ *Ibid.*, 97.

an enormous advantage with which the decentralized, agricultural South could not and did not compete. Lewis B. Parsons, a Yale graduate with a law degree from Harvard and a personal friend of General George McClellan, was an example of the, "honest, smart, and hard-working men" who were leading the integrated supply system, recording while organizing and directing.³⁰ Parson kept detailed quantitative records of shipments, Federal quartermasters moved a grand total of 3,982,438 people during the last fiscal year of the war (ending June 30, 1865), if that number, 3,376,610 were soldiers under orders from their commanders to go from one point to another. Additionally, 201,106 were soldiers going to or from their homes on furlough. Another 256,693 men were prisoners of war. In addition, army quartermasters moved 148,629 civilians who elected to travel on government transport. Parsons also moved 716,420 animals during the last fiscal year of the war. That included 407,629 horses, 123,448 mules, and 185,124 cattle. Parsons kept records during the last fiscal year of the war. More than 4.1 million tons of food for soldiers, over 3.7 million tons of quartermasters stores, 1.3 million tons of ordnance stores, nearly 90,000 tons of medical stores, and 127,000 tons of miscellaneous materials found their way by steamer, rail, and coastal shipping to military destinations.³¹ All supply transportation means were important, but the railroads moved men and goods over land to battle sites. Even at the beginning of the war the North had the edge with miles of railroad track and rolling stock. In 1861, the North had 22,000 miles of track and the South had only 9,000 miles. In both areas the gauges ranged from four feet by eight and half inches to five or six feet, and trains sometimes needed to be unloaded and reloaded.³² This meant that communication concerning scheduled supply and troop movements to minimize loading efforts were that much more difficult. Scheduling plans were developed with precise sequencing. Then, telegraph messages relayed commands for redirecting less important trains to side tracks and manually switching and re-switching to provide for continuous travel by more important through traffic.

³⁰ *Ibid.*, 30.

³¹ *Ibid.*, 261.

³² *Ibid.*, 9.

A brief accounting of the development of the railroad/telegraph integrated system sheds light on the extent to which the civilian systems became united and expansive. In 1861 Simon Cameron was the Secretary of War for the Union. He enlisted Thomas A. Scott, a civilian and general manager of the Pennsylvania Railroad to be in charge of all, railroad and telegraph lines needed for the war. Thomas Scott, in turn enlisted young Andrew Carnegie, superintendent of the Pittsburg Division of his railroad to Washington. This was the beginning of the coordination of all railroads and telegraphy needed for the war. Congress was not in session and in the absence of an appropriation, the president of the American Telegraph Company, which did much of the construction, operation and maintenance of the system, advanced funds. General George B. McClellan, who had studied military telegraphs used on a limited scale in the Crimean War, had realized the potential use of electrical telegraphy and put Anson Stager, general superintendent of Western Union, in charge of "private lines" for McClellan's own use.

McClellan organized a field telegraph system that moved with him into western Virginia - the first field telegraph that ever advanced with an army in America. After the Union demoralization at First Manassas, McClellan, whose strengths were engineering and organization (not field command) made Anson Stager "superintendent of military telegraphs." With the help of Thomas R. Eckert, who was to become president of Western Union, Stager developed the systems of military telegraphy that became fundamental to military operations and a vital factor in Federal victory.³³

Stager made wondrous advances in a short time. 1,137 miles of wire for military uses were strung in five months. Wires followed the army's line of march at a rate of often 8 to 12 miles per day.

Growth was rapid - by the end of the fiscal year 1862, 3700 miles were in operation; 1800 miles were added the following year, 3700 in 1863, another 3300 in 1864, and 2000 more in the final year of the war. Altogether, the military telegraph lines were enough to stretch more than halfway around

³³ David Homer Bates, *Lincoln in the Telegraph Office: Recollections of the United States Military Telegraph Corps during the Civil War* (Lincoln, NE: University of Nebraska Press, 1995): xii- xiii.

the earth - a prodigious achievement of American technology and organizational skill.³⁴

As previously noted, the center for military telegraphy was in the War Department, a short walk from the White House, and President Lincoln made it his personal information headquarters. His was an active commander in chief who used the new electromagnetic telegraph to follow and supervise military actions.³⁵

In the field, electrical telegraphy was used for tactical purposes, conveying information back to the War Department and for receiving strategic commands from the president and central command. The U. S. Army Signal Corps created a "movable field telegraph" housed in a supply wagon. It was horse drawn and could carry the equipment necessary for a working system. These wagons carried batteries, poles and reels of insulated wire from around five miles. Well-trained teams could deploy a working system within several hours.³⁶ Wires were constantly being sabotaged by opposing sides and were subject to "accidental disruption" from natural causes.³⁷ The use of these Union telegraph wagons occurred fairly early in the war, such as at Fredericksburg and Chancellorsville.³⁸

Another use of the new telegraphy was for reporting information from both Southern and Northern balloons, or portable observation platforms. While much of the time communications from the hydrogen balloons several hundred or more feet above the battlefield were transferred through written messages dropped or slid along ropes, some balloons had telegraph keys in the balloon baskets and wires with receivers on the ground.³⁹ Communications concerning gun and troop placements were relayed almost instantaneously. Such information could then be used to direct artillery fire, pinpoint areas of vulnerability for attack, or give advanced warning of the

³⁴ *Ibid.*, xii.

³⁵ *Ibid.*, xiv.

³⁶ Barton C. Hacker, Ed. *Astride Two Worlds: Technology and the American Civil War*. (Washington, D. C.: Smithsonian Institution Scholarly Press, 2016): 99.

³⁷ *Ibid.*

³⁸ *Ibid.*

³⁹ *Ibid.*, 97.

need for defensive measures. Through constant development, portable electrical telegraphy was finding a place in communicating localized tactical information as well as being used for higher-level command and control.

In summary, the American Civil War saw great changes in military communications through electrical telegraphy. The integration of telegraphic communications and more flexible railroad rapid supply and re-supply, gave the Union a powerful military advantage. Year by year, Lincoln made better use of the telegraph to manage the war, at first just getting reports from field commanders and later issuing orders from a central command with a larger picture of the entire theatre of operations. Lincoln was a hands-on commander with direct communications with War Department's chief, General Winfield Scott and localized battlefields. The North's portable telegraph units allowed for more precise incoming intelligence, which Scott and Lincoln successfully used. Lincoln's favorite saying in stressful moments of potential local battlefield success, conveyed by the telegraph, was that the situation was now "down to the raisins," a somewhat off-color and folksy Lincolnesque reference to a young girl who had "over-indulged in the food at her birthday party, topping it all off with raisins." She, then subsequently had a serious regurgitation episode with a grand finale that included the raisins. The telegraph brought excitement, trepidation and sometimes the necessity for rapid central command decisions.⁴⁰ Lincoln's telegraph messages are on file in the Finally, the electrical telegraph came into its own as a source of press communications. Local news dominated newspaper coverage in the United States before the Civil War. With the coming of the war, the public gained a desire for fresh news from beyond the local scene. The military had priority with telegraph use. It was costly to send messages during the war, for instance, a telegraph from Washington to New York cost five cents per word. The press, invented pooling of resources to lessen reporter costs in the field and telegraph costs to send the news back home. This contributed to the creation of the Associated Press, which added to the transparency of the

⁴⁰ Tom Wheeler, *Mr. Lincoln's T-Mails – How Abraham Lincoln Used the Telegraph to Win The Civil War*, 11-12.

progress of the war but also added to opportunities to critique the leadership.⁴¹

The telegraph, which had given Abraham Lincoln unprecedented capability for a chief magistrate, also brought to the American people an unprecedented awareness of and vicarious participation in both battlefield events and political intrigue. This, in turn, created new challenges for the president for which, once again, he was without precedent or guidance.⁴²

War management now had the additional component of managing the news, of what would now be said to be controlling the “talking points,” the “narrative,” or the “spin.” Lincoln had recognized the importance of public opinion two years previously in the Lincoln-Douglas debates. He said:

Public sentiment in this country is everything. With public sentiment, nothing can fail; without it nothing can succeed. The development of public opinion meant that “he who moulds public sentiment, goes deeper than he who enacts statutes or pronounces decisions.” To prevail in the rebellion, the president knew he needed to mold public sentiment.⁴³

The electrification of warfare added a new dimension to military/political leadership. Mainly, the public demand for more immediate information through the use of telegraph by the print press. Lincoln realized this but did not have the propaganda personnel or the tools of control that he might have wished. Warfare and politics were again changing, due to new technology and a better understanding of its scientific base.

⁴¹ *Ibid.*, 94.

⁴² *Ibid.*, 95.

⁴³ *Ibid.*