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Connecting the Dots and Dashes: Wireless Telegraphy Communication in the Canadian Expeditionary Force, 1914–1918

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Abstract: This article seeks to explain wireless telegraphy (W/T) equipment, its development and use over the course of the First World War and how W/T performed in conjunction with the established landline network. W/T deployment during Canadian Expeditionary Force battles is evaluated to determine whether W/T was viewed as an alternative battlefield communication medium or simply as a standby for emergency situations. The analysis discloses that the Canadian infantry was unable to take advantage of continuous wave, a superior form of wireless that the artillery relied upon. This article contends that by war's end W/T had become a viable substitute for traditional wired networks, but was underutilised whenever the cable grid was operational.

A CANADIAN BATTALION SIGNALLER ("dot-and-dasher") wrote: "Communication was the blood in the arteries of War, and any neglect in this vital area would quickly weaken, if not endanger, the lives of the fighting men up front."[1] John Terraine claims that early twentieth century technology is the key to understanding the First World War.[2] Andrew McNaughton, who commanded the Canadian Corps Heavy Artillery, declared: "1917 was a year of application of

[1] Victor Wheeler, *The 50th Battalion in No Man's Land* (Calgary: The Alberta Historical Resources Foundation, 1980), 261.
[2] John Terraine, "Understanding," *Stand To!* 34 (Spring 1992): 9.

engineering and science to the technique of war."[3] According to Tim Travers, the impact of technology in 1918 was one of several factors that brought victory.[4] The First World War's four essential technologies were weaponry, transportation, aviation and telecommunications.[5]

Although not infallible, communications were conceivably "the life of operations."[6] Control of battle was restricted to what the transmission mechanisms conveyed to General Headquarters (GHQ) and to army, corps, division, brigade, battalion, company and battery headquarters. More importantly—during the fog of war—accurate tactical information had to be communicated in real-time from all units and formations to decision makers at command and staff levels.[7] At times, an intelligence vacuum existed in the command structure. Paddy Griffith maintains that in an attack, the unavoidable delay in message transmission between the front line and high command probably was the one factor preventing a decisive breakout.[8] According to Brigadier Shelford Bidwell, an initial breakthrough could not be exploited until interrupted communications were restored.[9] Corps staff on occasion possessed more information (received from contact aircraft) than divisional or brigade officers; this intelligence had to be forwarded.[10] Lacking communications, "[t]he army is then fighting

[3] "Discussions of Military Tactics, Weaponry and the Leaders," Chapter 11, Disc 2, *Flanders' Fields: Canadian Voices From WWI*, directed by J. Frank Willis (CBC Audio, 2006), DVD; and CBC Radio interviews, accessed 29 June 2020, https://www.mediafire.com/folder/pnu2i8222l7j2/S3_Flanders_Fields_Transcripts.

[4] Tim Travers, *How the War was Won: Command and Technology in the British Army on the Western Front, 1917-1918* (Barnley, UK: Pen & Sword Military Classic, 2005), 2.

[5] Michael Crawshaw, "The Impact of Technology on the BEF and its Commander," in *Haig: A Reappraisal 70 Years On,* ed. Brian Bond and Nigel Cave (Barnsley, UK: Leo Cooper, 1999), 160.

[6] War Diary [WD], 10th Canadian Infantry Brigade, August 1918, Appendix D, RG9 III-D-3, Volume 4903, File 311, Library and Archives Canada [LAC].

[7] For a general understanding of the various methods of communications in the First World War, see Bill Rawling, "Communications in the Canadian Corps, 1915-1918: Wartime Technological Progress Revisited," *Canadian Military History* 3, 2 (1994): 6-21.

[8] Paddy Griffith, *Battle Tactics of the Western Front: The British Army's Art of Attack 1916-18* (New Haven, CT: Yale University Press, 1994), 174-75.

[9] Shelford Bidwell, *Modern Warfare: A Study of Men, Weapons and Theories* (London: Allen Lane, 1973), 82.

[10] Andrew Simpson, *Directing Operations: British Corps Command on the Western Front 1914-18* (Warwick, England: Helion & Company, 2019), 71.

without a brain; or worse still, with a disordered brain which acts regardless of reality."[11]

Publications and studies, past and present, of wireless telegraphy (W/T) development and deployment during the First World War are examined to assess W/T effectiveness on the Western Front and, in particular, its bearing on Canadian Corps' operations. Five contributors, three of whom served in a military signalling capacity during the war, are referenced frequently. Basil Schonland, British Signal Service wireless officer, published a four-part series of wireless articles in 1919. Raymond Priestley, Royal Engineer officer in wireless operations and training, wrote an account in 1921 of the British Signal Service in the First World War. William Arthur Steel, 4th Canadian Divisional Signal Company officer and later Canadian Corps Signal Company officer, wrote an eight-part series of wireless articles from 1929 to 1931 based on a wireless communication report issued in 1919. Laurence Lyons and Mike Bullock have written the first book-length study on British signals in the First World War since Priestley. Brian Hall has contributed significantly to the latest scholarship on communications on the Western Front and other operational theatres.

In an on-going academic debate, the duo of Bullock and Lyons contend that British high command possessed neither the vision that continuous wave (CW) wireless would "revolutionize command and control" nor the will to deploy resources necessary to engineer reliable CW wireless sets and this "institutional bias" prevented enhanced communications.[12] Hall maintains the British Army exploited the "full military potential" of wireless during the war and in particular of CW wireless in 1918.[13] Rather than engaging in this discussion, the focus of this article is the Canadian infantry, artillery and cavalry formations' effort to organise, issue and use W/T on the Western Front. Wireless capabilities during both static and open warfare are analysed to determine W/T's impact upon military operations.

[11] *Report of the Committee on the Lessons of the Great War Appendix II* (The War Office, 1932; reprint, Uckfield, UK: Naval & Military Press, 2013), 45.

[12] Mike Bullock and Laurence Lyons, *Missed Signals on the Western Front: How the Slow Adoption of Wireless Restricted British Strategy and Operations in World War I* (Jefferson, NC: McFarland & Company, 2010), 193-94; and Mike Bullock and Laurence Lyons, "Response to Dr Brian N. Hall's Articles on British Wireless in the First World War," *War in History* 23, 2 (April 2016): 237.

[13] Brian Hall, "The British Army and Wireless Communication, 1896-1918," *War In History* 19, 3 (2012): 319; and Brian Hall, *Communications and British Operations on the Western Front, 1914-1918* (Cambridge: Cambridge University Press, 2017), 303.

Although W/T was underutilised whenever wired communications were available, W/T was a valuable tactical contribution to army communication. Newer wireless technology in 1917 enabled W/T to become an integral part of battlefield communications. It was a reliable auxiliary system to land-based communications and was effective in handling emergency situations. But overall, its advantages did not outweigh its disadvantages. Tenuous W/T was not a war-winning communication technology; it had not sufficiently matured in the last months of the war to be considered the primary alternative to conventional methods of communications in the front lines.

ARMY WIRELESS TELEGRAPHY SETS AND TECHNOLOGY 1914-1918

Although the Royal Navy was already the world's principal user of W/T[14]—after twenty years of development it was a mature technology "uniquely suited for naval communications"[15]—army W/T was in its infancy in 1914. Morse code-based W/T sets utilised crystal detector receivers[16] and spark-gap transmitters. High voltage applied across the gap between two mushroom-shaped conductors caused a spark to jump the gap, generating a train of electromagnetic oscillations which rapidly died out. Its aerial's radiation generated excessive interference into space on a wide radio-frequency band. Spark wireless required broad tuning and when a large number of sets operated on the same narrow frequency band, they interfered with each other.[17] Fundamentally, a spark transmitter was "a dirty radiator, polluting the spectrum with radiation."[18]

A year before the outbreak of war, a report had stated wireless communications in the British Army were "so inefficient as to be

[14] Kapil Subramanian and Graeme Gooday, "British Telecommunications History in the First World War," in *Britain and the Widening War 1915-1916: From Gallipoli to the Somme*, ed. Peter Liddle (Barnsley, UK: Pen & Sword Military, 2016), 214.
[15] A.J.L. Blond, "Technology and Tradition: Wireless Telegraphy and the Royal Navy 1895-1920" (PhD dissertation, University of Lancaster, 1993), 134, 363.
[16] Pre-war, the coherer and the Marconi magnetic detector was used for receiving Morse code messages.
[17] W. Arthur Steel, "Wireless Telegraphy in the Canadian Corps in France," *Canadian Defence Quarterly* 7, 4 (July 1930): 458.
[18] Hugh Aitken, *Syntony and Spark: The Origins of Radio* (Princeton: Princeton University Press, 1985), 73.

unreliable, and therefore practically valueless, in time of war."[19] Nevertheless, the British Expeditionary Force mobilised for war with spark technology: Pack sets, Motor Lorry sets and Wagon sets. The 500-watt 600-lb Marconi Pack set's transmitter operated on a 550, 650 or 750 metre wavelength and its receiver on wavelengths from 300 to 1,300 metres. The horse-drawn apparatus included two 30-foot-high masts. Pack set to Pack set range was 20 to 25 miles.[20] The GHQ-based 1,500-watt petrol engine-powered Motor Lorry set covered a 100-mile range with two 70-foot masts. The six-horse drawn 1,500 watt Wagon set was equipped with an 80-foot mast, a transmitter and a receiver with a 100-mile range. A Pack set could transmit over 30 miles to the Wagon set. These wireless stations were assembled in fifteen to twenty minutes.

Battalion, brigade and divisional headquarters required field wireless sets. In August 1915, the British Field (BF) Trench set was designed for forward work.[21] A three-man crew operated this 50-watt DC spark transmitter/receiver telegraphy set. The set broadcast over a 4,000 yard range between BF sets when two 15-foot masts supported the aerial. The transmitter operated on a 350, 450 or 550 metre (857 kHz, 667 kHz or 545 kHz) wavelength.[22] The aerial extended from 60 to 80 yards, depending on wavelength. A dummy rifle grenade could be used to hoist the aerial onto a tree to make it less conspicuous.[23] The receiver covered a wider band of 200 to 600 metres (500 kHz to 1.5 MHz). A six-man carrying party moved the 31-lb set, along with accumulators (rechargeable batteries), masts, aerial wire, earth mats (simulated ground connections for aerials) and gear; a combined station weight of about 150 lb. Keeping exposed masts standing during shellfire was almost impossible. A station would resort to insulated

[19] Hall, "The British Army and Wireless Communication," 291.
[20] *Stationery Service (SS) 141 Communication by Wireless,* March 1918, RG24-C-6-k, Volume 22022, LAC.
[21] Bullock and Lyons, *Missed Signals on the Western Front,* 46. The BF set was trialled at the Battle of Loos.
[22] A century ago, electromagnetic waves were expressed in wavelengths. The higher the frequency (Hertz), the shorter the wavelength (metres).
[23] *Technical Instructions No. 7, Wireless Trench Set, D.C. 50 Watts*, April 1918, RG24-C-6-k, Volume 22020, LAC.

ground aerials, which reduced its operational range.[24] A shell's thump outside the station's dugout could knock the adjustment off course.[25]

In mid-1915, the 130-watt Wilson set containing a spark transmitter for use as a directing station (control station) at army, corps and divisional headquarters replaced the Pack set.[26] A three-man crew operated it on one of three wavelengths: 350, 450 or 550 metres. The range from a BF set to a Wilson set was about 7,000 yards and Wilson set to Wilson set 9,000 yards. The aerial wire length was 55 yards for 350 metres, 75 yards for 450 metres and 95 yards for 550 metres, supported by 45 to 70 foot masts. As directing stations, the tuning had to be sharp. The Mk. III Short Wave Tuner received on 100 to 700 metre wavelengths. An aerial 60 to 100 yards long hung on two 30-foot steel tubular masts.[27]

The army directing station maintained a separate aerial and receiving set for each wavelength allotted to a corps. A corps directing station (averaging 5 to 15 miles behind the front line) controlled subordinate stations. It assisted when they missed calls and acted as a divisional headquarters station when one was temporarily out of action, transmitting directly to a brigade station.[28] Each division was in close liaison with its advanced divisional headquarters, brigades, artillery and flanking divisions.

A directing station could impose controlled working: one in a group of stations was ordered to stop transmitting if another had an urgent message to send. When this proved impossible owing to interference, the chief directing station operator would choose period working by setting time periods (typically five minutes). The other stations would conform exactly, taking their turns.[29] A wireless

[24] Basil Schonland, "W/T. R.E.: An Account of the Work and Development of Field Wireless Sets with the Armies in France," *The Wireless World* 7, 76 (July 1919): 176.
[25] The Germans captured the BF set, repackaging it as a Telefunken trench set. See Schonland, "W/T. R.E.," 7, 76 (July 1919): 176.
[26] Raymond Priestley, *Work of R.E. in the European War, 1914-19: The Signal* Service *(France)* (Chatham, UK: W & J Mackay, 1921; reprint, Uckfield, UK: Naval & Military Press, 2006), 87.
[27] *Technical Instructions No. 8 Wilson W/T Transmitting Set*, April 1918, RG24-C-6-k, Volume 22020, LAC; and *SS 141 Communication by Wireless*, March 1918, LAC.
[28] *Technical Instructions No. 6 Control of Wireless Communication*, February 1918, RG24-C-6-k, Volume 22020, LAC.
[29] *SS 209 Handbook of Procedure Wireless Telegraphy*, March 1918, RG24-C-6-k, Volume 22022, LAC; and *Handbook of Procedure For Use With Wireless Signal Stations in the Army*, 1912, RG24-C-6-k, Volume 22020, LAC.

operator would transmit as many messages as possible before losing priority. The operator would then continue to listen for any emergency calls.[30] The divisional, corps or army directing station corrected any problems arising from jamming (interference from an enemy or neighbour's transmitter).[31] Operators also watched for carelessness in enciphering, kept stations on their proper wavelengths, assisted with their more powerful sets and checked messages sent in clear (not enciphered).[32] Careful monitoring exposed procedural mistakes and ensured all operators observed protocol.[33]

The 20-watt Loop set, for forward area communications between brigades and battalions and between battalions and companies, was introduced in 1917. Its 74-lb front set and 82-lb rear set each contained a transmitter, receiver, accumulator (fully recharged after thirty-six hours) and aerials. A three-man crew carried the front set. Its diamond-shaped transmitting aerial, or loop (four light brass collapsible rods), was attached to a small ebonite box containing the transmitter's spark-gap and condenser. This was clipped onto a bayonet driven into the ground, with a cable leading to the operator 20 feet away at the transmitter.[34] The transmitting loop could be completely screened from enemy observation when placed in a shell hole, trench or dug-out with little weakening of signal strength. Its receiving aerial (made from two 35-foot insulated-wire lengths) was tossed on the ground from the shell hole or trench. The rear Loop set's aerial (35 to 60 feet long supported on two 4-foot tripod masts) handled transmissions and receptions.[35] Several aerials were erected for a spark set when shelling was intense. These true short-wave sets worked on a fixed wavelength of 65 or 80 metres (4.615 or 3.750 MHz) with a 2,000 to 4,000 yard range. A rear set operator could be as far

[30] Bertram Neyland, "A Wireless Operator," in *Everyman At War: Sixty Personal Narratives of the War*, ed. C.B. Purdom (London: J.M. Dent & Sons, 1930), 107-13.
[31] Jamming became disruptive when a Loop set and a BF set were 500 yards apart. See *Signalling Notes No. 16,* RG9 III-C-5, Volume 4443, Folder 7, File 3, LAC.
[32] In the Canadian Corps, wireless messages could only be sent in clear for SOS alerts, artillery reports for ranging or knowledge about fleeting targets, plus messages containing less than five words. See Wireless Messages, 18 September 1918, 3rd Canadian Division, RG9 III-C-5, Volume 4388, Folder 16, File 15, LAC. For an example of a simple substitution cipher, see Appendix A: Substitution Cipher Using Keyword.
[33] Schonland, "W/T. R.E.," 7, 79 (October 1919): 395.
[34] Schonland, "W/T. R.E.," 7, 80 (November 1919): 452.
[35] *SS 141 Communication by Wireless*, March 1918, LAC; and *SS 191 Inter-Communication in the Field,* November 1917, RG24-C-6-k, Volume 22000, LAC.

The transmitter and receiver of a Rear Station Mk II Wireless Telegraph Set Forward Spark 20 watt B ("Loop Set"). [Joe Costello, RCSigs.ca]

as 25 to 30 feet from the aerial. BF set transmitters could disrupt Loop set communication and Loop set receivers could be jammed by interference from nearby telephones.

The Power Buzzer (Earth Induction set), while not strictly a W/T set, was sufficiently similar in its method of earth induction telegraphy to be classified as a wireless apparatus. Small pulsating currents passed into the ground from a battery-driven induction coil by two insulated field cable lengths laid along the ground. Each of these wires was connected to the induction coil at one end and to an iron earth-pin hammered into the ground at the other. The current impulses were received at a second set of earth-pins and leads connected to a powerful vacuum tube (thermionic valve) Amplifier, which magnified the incoming signals.[36] The range between Power

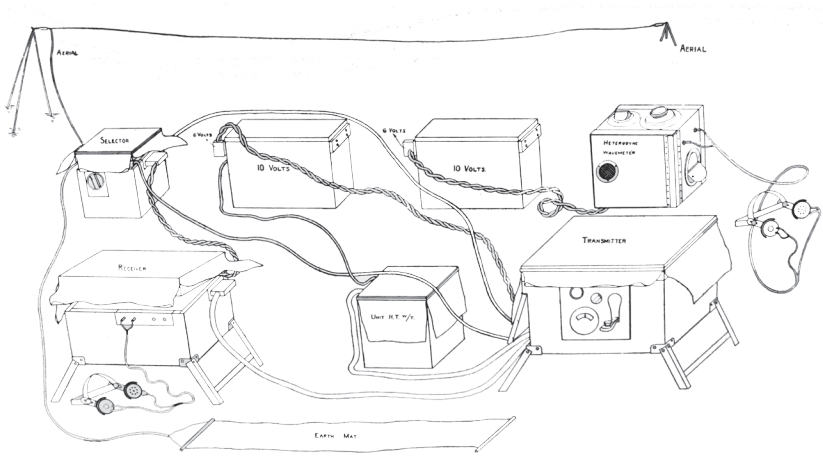
[36] In 1918 British Intelligence agents sabotaged Germany's wireless receiving station in Mexico City by destroying all the receiver's vacuum tubes. See Jonathan Winkler, "Information Warfare in World War 1," *The Journal of Military History* 73, 3 (July 2009): 854.

Buzzer and Amplifier could extend from 2,000 to over 4,000 yards, depending on the soil's conductivity.[37]

The Power Buzzer, adapted from the French *Parleur* instrument, weighed 7 lb and its 26-lb accumulator provided fourteen hours continuous work. The Amplifier (accumulators, boxes and cables) weighed 130 lb. Signallers transmitted in code—substituting a numerical or alphabetical code word for a plaintext word—as the enemy could intercept and overhear the messages.[38] The Amplifier could not transmit so the Power Buzzer would repeat the message until a signaller at the Amplifier acknowledged receipt using a "flapper" or a rocket.[39] British Signal officer Reginald Nalder argued that a lighter form of the Power Buzzer-Amplifier, in sufficient quantities for battalion use, would have been worth more than spark wireless sets.[40]

The CW Trench Set Mk. I, designed in 1916, was introduced in 1917 after undergoing modifications.[41] CW was a "continuous, almost pure, [electromagnetic] sinusoidal waveform that was produced by keying" an oscillating triode vacuum tube.[42] Poulsen oscillating arcs and radio-frequency alternators also generated CW. Lighter and more portable than a spark set, a CW set worked from lower masts and shorter aerials, giving a greater transmission range with much less power expenditure, resulting in more effective use of the spectrum. Sharp tuning permitted four times more sets to operate in a given area without interfering with one another.[43] Although Telefunken had developed radio-frequency alternators by 1914, the Germans failed

[37] Steel, "Wireless Telegraphy," 7, 1 (October 1929): 45; and *Technical Instructions No. 5, Power Buzzer-Amplifier*, November 1917, RG24-C-6-k, Volume 22020, LAC.
[38] *SS 148 Forward Inter-Communication in Battle*, March 1917, 25, RG24-C-6-k, Volume 22000, LAC.
[39] WD, 2nd Canadian Divisional Signal Company, April 1917, RG9 III-D-3, Volume 5005, File 690, LAC; and *Military Operations France and Belgium 1917 Volume 1: Appendices* (London: MacMillan, 1940), Appendix 12, Section 5.
[40] Reginald Nalder, *The Royal Corps of Signals: A History of its Antecedents and Development* (London: Royal Signals Institution, 1958), 130.
[41] A.G.T. Cusins, "Development of Army Wireless During the War," *IEE Journal* 59, 303 (July 1921): 766.
[42] Hall, *Communications and British Operations on the Western Front*, 100.
[43] Steel, "Wireless Telegraphy," 7, 1 (October 1929): 50.



W/T Sets Trench, CW, Mk. III. [Reproduced from *W.T. Sets, Trench, Continuous Wave, April 1918*]

to deploy vacuum tube CW sets.[44] A captured German document disclosed the British had secured the lead with CW-driven aircraft communications.[45]

The 30-watt CW Trench Set Mk. III transmitted and received on 450 to 1,450 metre (207 to 667 kHz) wavelengths. Its 20 to 100 foot-long aerial was suspended 2 to 4 feet above ground for forward work, with ranges from 4,000 to 6,000 yards.[46] A six-man party carried the seven boxes (transmitter, high tension unit, receiver, selector, wavemeter and batteries), earphones, earth mat, masts, aerial reels and spare vacuum tubes.[47] CW sets could send and receive without

[44] Hugh Aitken, *The Continuous Wave: Technology and American Radio, 1900-1932* (Princeton: Princeton University Press, 1985), 251; and Steel, "Wireless Telegraphy," 7, 3 (April 1930): 369. Telefunken created a variant of the quenched spark-gap system that supposedly behaved closely to CW. See Peter Hugill, *Global Communications since 1844: Geopolitics and Technology* (Baltimore: The Johns Hopkins University Press, 1999), 89-90.

[45] T.V. Smith, "Wireless in the Royal Flying Corps During the War," *The Electrician* 83 (October 1919): 447.

[46] Experimental work with high aerials extended the CW set Mk. III's range up to 100 miles. A 120-watt CW semi-portable set worked up to ranges of 200 miles. See *The Work of the Royal Engineers in the European War, 1914-19: Supply of Engineer Stores and Equipment* (Chatham: Secretary, RE Institute, n.d.), 64-65.

[47] *SS 191 Inter-Communication in the Field*, November 1917, LAC; *SS 141 Communication by Wireless*, March 1918, LAC; and *W.T. Sets, Trench, Continuous Wave*, April 1918, RG24-C-6-k, Volume 22020, LAC. Note: *SS 191* included and revised *SS 148*.

Table 1. Characteristics of Canadian-deployed W/T sets on the Western Front[i]

Set	Technology	Power (Watts)	Range (yards)	Frequency (metres)	Year Available	Mast Height (ft)	Station Weight (lbs)
BF Trench Set	spark	50	4,000	350, 450, 550	1915	15	150
Wilson Set	spark	130	7,000 to BF set; 9,000 to Wilson set	350, 450, 550	1915	45-70	140 (includes Mk. III Tuner)
Loop Set	spark	20	2,000 - 4,000	65, 80	1917	4	74 front station, 82 rear station
Woolwich Mk. I Trench Set	continuous wave	30	8,800	500-1,400	1917	15	unknown
Mk. III Trench Set	continuous wave	30	4,000 - 6,000	450-1,450	1917	2–4	175

Range varies depending on length and height of aerial.

[i] Compiled from *Technical Instructions No. 7 Wireless Trench Set, D.C. 50 Watts* , April 1918, LAC; *Technical Instructions No. 8 Wilson W/T Transmitting Set* , April 1918, LAC; *SS 141 Communication by Wireless* , March 1918, LAC; and *W.T. Sets, Trench, Continuous Wave* , April 1918, LAC.

risk of jamming other wireless sets, but spark sets interfered with them. For example, a BF set transmitting within 500 yards could jam a CW set receiving messages.

For a time, CW wireless remained almost entirely an artillery monopoly although a forward observation officer (FOO) could send urgent infantry-based messages. Furthermore, CW sets operated with anti-aircraft sections, tanks, scouting parties, Royal Air Force (RAF) ground stations (connecting brigades, wings and squadrons), the Canadian Independent Force (CIF) and the Canadian Corps Survey Section (CCSS). The corps directing station controlled both spark and CW wireless messaging.

Had the Canadian Corps infantry been allotted the superior CW sets, they would have benefitted from reduced mutual interference on narrow fronts. Indeed, the paramount hindrance to CW operations was jamming from spark sets. Uninterrupted communications over longer distances to headquarters in the final months would have been attainable, thereby avoiding spark-based stepping-up stations and bridging the augmented gap between formations with visual signalling. GHQ policy mandated that artillery, not infantry, would deploy CW wireless equipment in 1917. The artillery's long-range networks demanded the greater ranges obtainable by CW sets. Finally on 26 October 1918, a CW set Mk. III at the Canadian Corps

message centre began operating between the corps and army and also to divisional artilleries.[48]

W/T NETWORKS AND THEIR DRAWBACKS

A network, in conjunction with the field telephone and telegraph cable grid, operated from the safely ensconced army headquarters to the hostile environment of battalion headquarters, forming the military's wireless chain of intercommunications.[49] This hierarchical network conveyed orders forward, percolated information back to parent formations and ensured cooperation of all arms and units.[50] W/T made communications viable between any two points within the operational range of sets, regardless of topography. Raymond Priestley maintained W/T was the critically important alternative communication method to the rear of battalion headquarters.[51] Indeed, "[t]he most serious deficiency in the Great War was an effective battalion rear link to brigade."[52] In his final despatch, Field Marshal Douglas Haig acknowledged wireless communication integration into the Signal establishment, albeit down to divisions.[53]

The infantry's spark-based grid was a hodgepodge: a 1,500-watt Motor Lorry set at army headquarters, Wilson sets transmitting between corps and divisional headquarters, brigade BF sets working back to divisional headquarters and either Loop sets or a Power Buzzer and Amplifier operating between brigade and battalion headquarters. Each Canadian division was issued twelve Loop sets in early August 1917.[54] Each brigade kept two Loop sets for forward

[48] In October 1918, a British division attempted to obtain a CW set from British Heavy Artillery. See Report on the Operations of the 63rd (RN) Division, RG9 III-C-1, Volume 3856, Folder 78, File 10, LAC.

[49] German army and corps headquarters W/T station ranges were 200 and 60 miles respectively. Each divisional sector maintained a wireless detachment consisting of: a station, an infantry section with thirteen portable sets and an artillery section with twelve portable sets. See Anon, *German Army Handbook, April 1918* (London: Arms and Armour Press, 1977), 119-20. In February 1918, each division added a wireless battalion of two platoons.

[50] *SS 148 Forward Inter-Communication in Battle*, March 1917, 3, LAC.

[51] Priestley, *Work of R.E. in the European War,* 325.

[52] Crawshaw, "The Impact of Technology on the BEF and its Commander," 175.

[53] *Sir Douglas Haig's Despatches*, ed. J.H. Boraston (London: J.M. Dent, 1920), 334.

[54] 4th Canadian Infantry Brigade, 5 August 1917, RG9 III-C-3, Volume 4112, Folder 40, File 1, LAC.

work. Advanced corps, divisional and brigade headquarters, together with forward communications centres, report centres, message centres, rear command posts and lateral links to flanking formations at each command level were merged into the static network. Each corps was allocated one of three wavelengths (350, 450 or 550 metres) for spark set operation.[55] In 1918, the Canadian Corps maintained thirty-four CW, thirty-two Loop, twenty BF and twenty-four Power Buzzer-Amplifier stations.[56]

CW sets operated at field and heavy artillery headquarters with connections to brigade and battery headquarters and to observation posts. Initially, CW sets were primarily assigned for forward observation work directing artillery fire, due in part to their inconspicuous aerials. Flash spotting messages were conveyed by wireless to batteries. The artillery's counter-battery CW network included aircraft transmitting to Field Artillery (FA) Observation Posts (OPs), which communicated with FA brigades and divisional artillery, which in turn corresponded with Corps Artillery. Airplane messages were also transmitted to Heavy Artillery (HA) OPs, then up the line to HA Brigades to the HA Counter-Battery Staff Officer and to Corps Artillery.[57]

Wireless technology had technical limitations and vulnerabilities. Bursting shells jarred a receiver's crystal detector, freezing weather wrecked steel masts and sets required a reasonably dry dugout. Lack of spare parts left damaged sets irreparable, requiring replacement. Sets were inoperative while awaiting recharged batteries (often a daily requirement). Charging plants and battery dumps could be exposed to shell fire. Aerials had to be maintained at all costs. The CW operator's repair skills were indispensable as "[t]here were literally dozens of ways in which the [early] sets might go wrong."[58] A lack of adequate transportation was a critical ongoing obstacle to efficient wireless communication. Transportation for CW stations was often unsuitable, necessitating retuning, overhauling or exchanging the delicate sets. Mattress springs were sometimes used to counter the shaking. BF and Loop sets—sent forward in an assault once an

[55] Schonland," W/T. R.E.," 7, 79 (October 1919): 395.
[56] *Report of the Ministry: Overseas Military Forces of Canada 1918* (London: The Ministry, Overseas Military Forces of Canada, c1919), 265.
[57] Andrew McNaughton, "Counter Battery Work," *Canadian Defence Quarterly* 3, 4 (July 1926): Appendix B.
[58] Priestley, *Work of R.E. in the European War*, 226.

objective had been captured—were not lightweight and Loop sets were useless in certain atmospheric conditions. Weary men could not carry cumbersome apparatus after long marches. Carrying party casualties meant delivery of incomplete sets. All CW devices were vacuum-tube based as were listening set amplifiers, navy and air force equipment. Vacuum tubes were difficult to produce and wartime demands severely strained their manufacture, creating a vacuum tube production crisis in 1918.[59]

According to the General Staff-issued pamphlet *SS 148,* during an attack a BF set could be employed at the Advanced Brigade Headquarters to communicate to its flanking brigades and divisional headquarters. A battalion forward command post during an attack would communicate with its companies and brigade using signallers, runners and a "pigeoneer." It was inadvisable to carry a BF set further than the Advanced Brigade Headquarters unless the equipment could be shielded from view.[60] Shellfire often wrecked exposed aerials and masts and commanders were fearful of interceptions at the "information-gathering edge."[61]

The edict to encipher insecure wireless messages prevented swift circulation of critical real-time information to headquarters staff, impeding decision making especially once battle conditions had changed. The lack of skilled telegraphers and operators poorly trained in cipher further delayed deliveries. In fact, standing orders specified that messages be enciphered by the sender and deciphered by the addressee. However, it was common practice for operators to handle the ciphering, an impossible task during heavy traffic. The effort to encipher was of questionable worth considering that the enemy would usually decipher messages within six hours.[62] Ironically, larger amounts of wireless traffic assisted the enemy in solving the ciphers and codes.

However, W/T's susceptibility to interception was also shared by other communication technologies. The field telephone, for example,

[59] Brian Hall, "Missed Signals? A reply to Mike Bullock and Laurence A. Lyons," *British Journal for Military History* 4, 3 (2018): 27; Blond, "Technology and Tradition," 129; and Guy Hartcup, *The War of Invention: Scientific Developments, 1914-18* (London: Brassey's Defence Publishers, 1988), 155.

[60] *SS 148 Forward Inter-Communication in Battle*, March 1917, 8, 15, 22, LAC.

[61] Bidwell, *Modern Warfare*, 86.

[62] Maj.-Gen. W.H. Anderson, memo, 28 May 1918, RG9 III-C-5, Volume 4384, Folder 3, File 7, LAC.

was also at risk and its use was regulated in the wired battlefield's danger zone—the 3,000 yards extending behind the front lines where enemy listening sets could intercept telephonic conversations, telegraphic buzzer messages and Power Buzzer messages.[63] There were two types of telephonic circuits. The "double line" or twisted cable metallic circuit permitted the current to flow out along one line and back along another. The current in a "single line" or "earth return" circuit coursed through a field cable from the sender's telephone to the receiver's telephone and, instead of using a second cable, was returned via an earth-pin at the receiver to another earth-pin at the sender to complete the circuit. Unfortunately, the current leaked from the earth-pins, radiating in all directions and from inadequately insulated or bare segments of cable, or by electromagnetic induction.

Interception, of course, was a two-way street. To eavesdrop on enemy telephone conversations, earth-pins driven into the ground were attached to buried cables meandering back to dug-outs housing tuners and amplifiers, which magnified telephonic and Power Buzzer return earth currents. The cable could also be attached to the enemy's barbed wire. Alternatively, looped wire positioned parallel to the enemy's cable used induction to acquire the information. The listening station was known as IT, referring to Intelligence Telephone, or IToc.[64] In December 1916, the Canadians maintained two IToc sets to intercept German conversations and another two to police their own conversations.[65] To ensure greater security, conversations (except for artillery observation and emergencies) were either banned or restricted in the danger zone. One monitored conversation in February 1917 involved a Canadian officer instructing the sender to divulge a situation report over the phone. The receiver refused it, as it was forbidden.[66] Beginning in August 1917, W/T-based tuners and amplifiers were used to intercept enemy wireless traffic in close proximity to the Canadians. On 15 March 1918 an enemy wireless message, revealing complete plans for a raid against Hill 70,

[63] *SS 191 Inter-communication in the Field*, November 1917, 87, LAC.

[64] The German equivalent was the Moritz station, which identified more "British units than all their other intelligence sources combined." See Jim Beach and James Bruce, "British signals intelligence in the trenches, 1915-1918: part 1, listening sets," *Journal of Intelligence History* 19, 1 (2020): 6.

[65] Beach and Bruce, "British signals intelligence in the trenches, 1915-1918: part 1, listening sets," 13.

[66] No. 4 IT Set Reports, RG9 III-C-1, Volume 3837, Folder 29, File 1, LAC.

was intercepted and deciphered. The information sent to the 12th Canadian Infantry Brigade allowed enough time to prepare and repel the attack successfully.[67]

Interception of both wireline and wireless communications necessitated encoding and enciphering sensitive traffic at the front. These restrictions reduced the risk of interception but proved to be a time-delaying drawback on the battlefield.

CANADIAN OPERATIONS ON THE WESTERN FRONT: HOW W/T WAS APPLIED ON THE BATTLEFIELD

First Canadian Divisional Signal Company sappers inaugurated the Canadian wireless service in spring 1915. They built a receiving set and operated a press bureau, passing on wireless press reports from England and France and propaganda from other countries.[68] The 2nd Canadian Divisional Signal Company was the first to handle wireless battle-related messages in March 1916. That same month, Princess Patricia's Canadian Light Infantry Captain John Van den Berg used a field telephone to contact wireless stations, which forwarded his encoded directions for controlling machine gun fire. In May, fire directions were transmitted 6,000 yards from an OP to a 9.2 inch howitzer siege battery in the Ypres salient using BF sets—the first instance of wireless-directed artillery spotting in the Canadian Corps.[69]

During the Battle of Mount Sorrel's opening day, 2 June 1916—after most telephone lines had been down for hours—wireless messages were transmitted. A forward wireless set in Sanctuary Wood fell silent; its broken aerials could not be replaced under the heavy bombardment. The message "urgent need for reinforcements" sent at 1 p.m. from the 4th CMR to 3rd Brigade via pigeon and then

[67] Steel, "Wireless Telegraphy," 7, 3 (April 1930): 365, 366, 369. Possibly the first instance of a Canadian intercepting a German wireless message occurred in Canada. An official communication in clear from the German Embassy in Washington, DC to the German Foreign Office in Berlin was inadvertently intercepted in northern Québec on 3 August 1914, the evening before the outbreak of war. As a result, a German gun-mounted ship was interned for the duration in the USA. See Charles Winter, 20 November 1936, RG24-C-6-e, Volume 1837, File GAQ-9-34, LAC.

[68] Steel, "Wireless Telegraphy," 6, 4 (July 1929): 445.

[69] Steel, "Wireless Telegraphy," 6, 4 (July 1929): 450.

wireless took forty-eight minutes. One brigade-to-division ciphered wireless message of about 160 words took over four hours to reach its destination.[70]

The Canadians operated two sets in the Pozières area on the Somme battlefield in August 1916. After the Sugar Factory was captured on 15 September, one BF set handled twelve important messages to brigade and division. The BF station was moved forward for the attack on Courcelette that afternoon and handled substantial traffic for the next nine days.[71] An artillery observer messaged his batteries via a German set found at the Sugar Factory.[72] During the entire 141-day Battle of the Somme, wireless stations transmitted about 4,000 messages, a meagre twenty-eight messages per day.[73] Maj.-Gen. Richard Turner, 2nd Canadian Division, ranked wireless communications last after telephone, visual signaling and pigeons.[74] Regardless of method, during static warfare orders despatched from the Corps could take six hours or more to reach company commanders.[75] By comparison, a German-delivered message on the Somme took between eight and ten hours to pass between divisional headquarters and the front line.[76]

The seven communications methods at Vimy Ridge in April 1917 were telephones, aircraft contact patrol, visual signalling, pigeons, runners, Power Buzzer-Amplifiers and W/T stations.[77] BF sets were

[70] WD, Canadian Corps Signal Company, 2-3 June 1916, Appendix B, RG9 III-D-3, Volume 5004, File 687, LAC.

[71] Steel, "Wireless Telegraphy," 6, 4 (July 1929): 452-54.

[72] WD, 21st Canadian Battalion, Operations 21st Canadian Battalion, September 1916, RG9 III-D-3, Volume 4930, File 410, LAC.

[73] Section IV, *SS 141 Notes on Wireless*, February 1917, RG24-C-6-k, Volume 22022, LAC.

[74] David Campbell, "The Divisional Experience in the C.E.F.: A Social and Operational History of the 2nd Canadian Division, 1915-1918" (PhD dissertation, University of Calgary, 2003), 256.

[75] *SS 119 Preliminary Notes on the Tactical Lessons of the Recent Operations*, July 1916, 7, REF TECH UB 251 G7 P7 1916, Canadian War Museum Military History Research Centre [CWM MHRC]. At the Somme in October 1916, the distance from Canadian Corps HQ to the 1st Division HQ was 17,500 yards, from 1st Division HQ to 1st Brigade HQ 4,375 yards and from 1st Brigade HQ to the 4th Battalion HQ 4,375 yards. See William Stewart, *Canadians on the Somme, 1916: The Neglected Campaign* (Solihull, UK: Helion & Company, 2017), Map booklet, Map S.2.

[76] David Zabecki, *The German 1918 Offensives: A case study in the operational level of war* (New York, NY: Routledge, 2009), 66.

[77] Duncan Macintyre, *Canada at Vimy* (Toronto: Peter Martin Associates, 1967), 90-91.

operational at the 1st Canadian Divisional report centre and at 2nd and 3rd Brigade headquarters, one in the Bentata subway.[78] Shell fire destroyed the 2nd Canadian Infantry Brigade's Power Buzzer and killed its operators. On the 2nd Canadian Divisional front, electromagnetic induction from buried telephone circuits jammed the Amplifiers. One of their two BF sets worked from inside Zivy Cave. Two BF sets were used on the 3rd Canadian Division's front. The 4th Canadian Division's two BF sets (one near Souchez and the other in the Tottenham Subway) and Power Buzzers readied for emergencies were never used. Spark wireless was underutilised, being non-essential at Vimy Ridge because well-maintained telephone and telegraph connections remained uninterrupted.[79]

Two British Heavy Artillery Groups at Vimy Ridge were allotted four CW sets, two forward and two rear. British and Canadian signallers operated these four field sets, transmitting on a 1,000-metre wavelength. No jamming occurred at the OP stations with the forward sets operating on 5-foot-high masts. The rear stations, 8,000 yards away, used 30-foot-high masts. FOOs despatched runners to the OPs, where CW wireless signallers relayed their messages with directions and attack status to the heavy guns.[80]

In preparation for the Battle of Hill 70, the first wireless Canadian gun registration occurred in late July 1917. CW wireless issued all messages and corrections to the artillery exchange at Bully-Grenay.[81] Canadian Corps Heavy Artillery (CCHA) counter-battery groups operated four CW sets. Signallers at fixed OPs relayed German troop movement and battery locations to Canadian gunners.[82] With ongoing disruptions to lines, a CW set on Hill 70 (Ascot OP) handled SOS calls every day. Wireless continued to be used as an emergency,

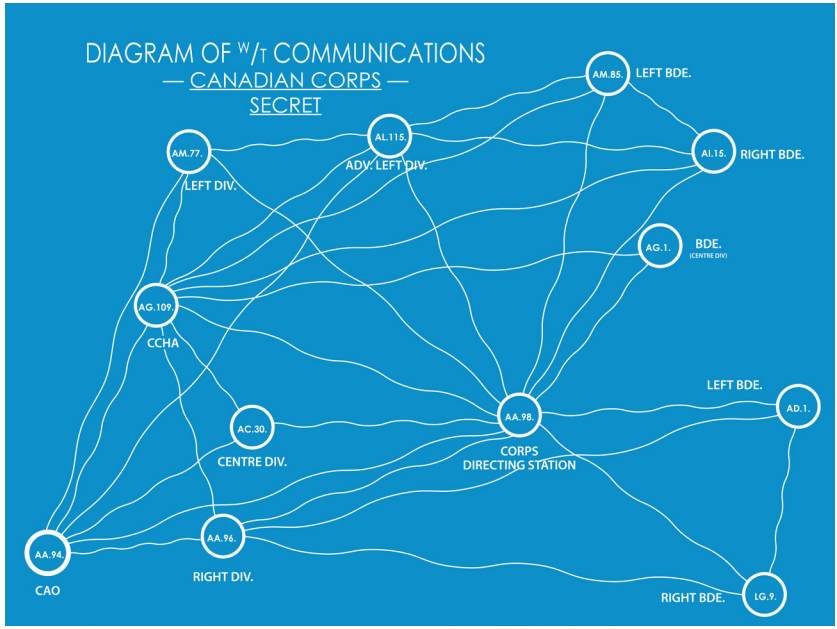
[78] A report centre was a forward collection station for ties between infantry, artillery and other formations.

[79] WD, 1st Canadian Divisional Signal Company, April 1917, RG9 III-D-3, Volume 5004, File 689, LAC; WD, 2nd Canadian Divisional Signal Company, April 1917, RG9 III-D-3, Volume 5005, File 690, LAC; WD, 4th Canadian Divisional Signal Company, April 1917, RG9 III-D-3, Volume 5005, File 693, LAC; and Steel, "Wireless Telegraphy," 6, 4 (July 1929): 458.

[80] Steel, "Wireless Telegraphy," 7, 1 (October 1929): 50-51.

[81] Steel, "Wireless Telegraphy," 7, 1 (October 1929): 51.

[82] Dan Jenkins, "Winning Trench Warfare: Battlefield Intelligence in the Canadian Corps, 1914-1918" (PhD dissertation, Carleton University, 1999), 295.



Major wireless telegraphy stations in the Canadian Corps zone circa early February 1918. [Reproduced from LAC RG9 III-C-5, Volume 4436, Folder 2, File 2]

rather than alternative, communication medium. For instance, a Wilson set handled only CCHA emergencies.[83]

Canadian infantry and artillery operated spark and CW wireless stations at Passchendaele. On 25 October, a direct hit destroyed the forward corps directing station in a dugout north of Menin Gate. A shell destroyed another near Zonnebeke after the enemy located it with a compass set (a listening station to detect an enemy's set).[84] 1st Canadian Divisional headquarters remained in wireless contact with one brigade at Gallipoli Heights, southeast of Gravenstafel. A directing station's Wilson set established communication with forward BF sets although jamming seriously disrupted transmissions. The attacking battalions carried Power Buzzers in November, but the Amplifiers' unsuitable accommodations led to disappointing results.

[83] WD, 1st Canadian Divisional Signal Company, August 1917, LAC; and WD, Canadian Corps Signal Company, August 1917, LAC.
[84] Steel, "Wireless Telegraphy," 7, 4 (July 1930): 463.

A 4th Canadian Divisional wireless aerial attracted fire.[85] Lieut.-Col. Elroy Forde, Assistant Director of Signals, reported that 3rd and 4th Canadian Divisional Signal Company stations had not received any calls for over three days.[86]

To test CW effectiveness, three stations were assigned to receive CCHA FOOs' reports from Passchendaele: a rear station at CCHA headquarters in the Vlamertinghe Château, a combined spark and CW station at divisional artillery headquarters at the Ypres Ramparts and a stepping-up (re-transmission) station at Gallipoli Heights. On 6 November, under an intense enemy barrage, the wireless team arrived at the Crossroads in Passchendaele at 9:10 a.m. with the forward station. A Wilson transmitter, a Mk. III Receiver, a Woolwich CW set Mk. I (replaced seven times during the operation owing to rough handling) and a Carden CW set (for cavalry use) were assembled inside a pill-box. For redundancy, three aerials were erected, all in different directions, because they were shot down, on average, twenty times a day from continual shell fire.[87] This counter-battery report centre coordinated artillery fire and also handled infantry messages. Spark wireless was rendered inoperable from jamming, faulty aerials and concentrated shelling. It was abandoned. Four hours after transmitting a message from the Woolwich CW set, a reply was finally received from the divisional CW set, about 11,000 yards away. Jamming from overhead aircraft transmitters and enemy spark stations was intense, but the CW signal remained loud and clear. Seventy-three messages were sent during a ten-day period. After this test, "staff were now willing to consider wireless as an integral part of the general scheme of communication."[88]

[85] WD, 1st Canadian Divisional Signal Company, October-November 1917, LAC; WD, 2nd Canadian Divisional Signal Company, October-November 1917, RG9 III-D-3, Volume 5005, File 691, LAC; WD, 3rd Canadian Divisional Signal Company, October-November 1917, RG9 III-D-3, Volume 5005, File 692, LAC; WD, 4th Canadian Divisional Signal Company, October-November 1917, LAC; and WD, Canadian Corps Signal Company, October-November 1917, LAC. Occasionally, aerials were raised or left as decoys.

[86] A.D. Signals, memo, 31 October 1917, RG9 III-C-1, Volume 3854, Folder 71, File 8, LAC.

[87] A German prisoner stated that the 1917 Battle of Messines' bombardment forced them to erect a ground aerial for every message sent. See Review of Enemy Wireless in Battle of Messines June 1st to 21st, 1917, MG30-E61, Volume 13, Folder 88, LAC.

[88] Steel, "Wireless Telegraphy," 7, 4 (July 1930): 458-62; and WD, General Officer Commanding [GOC] Royal Artillery [RA], Canadian Corps Artillery Report, December 1917, RG9 III-D-3, Volume 4957, File 504, LAC.

On 7 November, Lieut.-Col. Andrew McNaughton forwarded a test message simultaneously by wireless and pigeon to CCHA headquarters. The CW message, undoubtedly short and in clear, was received at headquarters less than five minutes after being handed in, before the pigeon had even left the pill box.[89] Nevertheless, pigeon service in 1917 was deemed more feasible than forward wireless.[90]

The Canadian Signalling School had been established in March 1917 in Sussex, England. Divisional CW wireless detachments for field artillery were established in early 1918 along with a CW field artillery school. Reorganisation of the Canadian Corps Signal Service was initiated in February 1918. An officer dedicated to wireless duties was added to each divisional signal company and additional transport was assigned for wireless equipment.[91] That same month, an extra Wilson set was secured for each division along with the formation of Brigade Buzzer and Loop set pools. By March, fifty-seven operators from artillery units had been trained in CW wireless. Between May and July, training schools were run for divisional W/T sections. The Canadian Corps Wireless School was established in June as part of the Canadian Corps Signal School in France. In July, W/T sections were reorganised and furnished with equipment. A special CW detachment was added to each division.[92]

In August 1918, each Canadian division at Amiens operated a Wilson-based directing station conversing with its brigades' BF sets. The corps directing station at St. Fuscien controlled all divisional and brigade traffic for over thirty-six hours. The forward station operated at the Corps report centre near Gentelles. The most wireless traffic (over 150 messages) occurred on 11 August while divisions were moving. Procedure called for advancing divisions to hand over their brigades' communications to corps, but the additional traffic

[89] Steel, "Wireless Telegraphy," 7, 4 (July 1930): 460. Curiously, during an interview in January 1963 for CBC's *Flanders' Fields* radio broadcast series, then 75-year-old McNaughton recalled the pigeon arrived at his headquarters in about thirty minutes whereas the wireless messages was received the next day. See John Swettenham, *McNaughton: Volume 1 1887-1939* (Toronto: Ryerson Press, 1968), 115.

[90] John Moir, *History of the Royal Canadian Corps of Signals 1903-1961* (Ottawa: Corps Committee Royal Canadian Corps of Signals, 1962), 28.

[91] Extracts from Correspondence re Re-organization of Signal Service, February 1918, RG9 III-C-5, Volume 4443, Folder 7, File 3, LAC.

[92] Major Donald White, 4 March 1918, RG9 III-C-3, Volume 4022, Folder 53, File 5, LAC; and Steel, "Wireless Telegraphy," 7, 4 (July 1930): 464-67.

became excessive—especially before new cabling was installed—when two divisions were on the move.

The Canadian Corps Signal Company was responsible for communications with flanking corps, divisions, heavy artillery, RAF squadrons, kite balloons sections, survey sections and anti-aircraft sections. It handled 1,423 wireless messages from 8 to 19 August from Corps Headquarters, the CCHA, the CIF and Liaison.[93] Canadian Corps headquarters exchanged situation reports with the French 31st Corps over CW wireless while staying in touch with the Australian Corps over spark wireless.

The 1st Canadian Divisional Wilson station communicated with its brigades, corps and flanking divisions, transmitting 95 per cent of 157 messages in clear from 8 to 12 August.[94] Throughout 8 August, 2nd Canadian Divisional wireless communication was hampered by numerous sets jamming at the front. The 3rd Canadian Division's close proximity to its brigades that day meant little wireless work initially. Later, they averaged forty messages daily from 12 to 15 August. The 4th Canadian Divisional Wilson station messaged the corps directing station for four hours non-stop on the 8th, blocking the other three divisions.[95] Of the 5,580 messages the 4th Canadian Divisional signallers handled from 8 to 15 August, only 250 were wireless.[96]

Although much jamming occurred and constant adjustments were required, "[w]ith the dislocation of the telephone and telegraph service during the greater part of the first day, … wireless as a means of communication for the first time in the history of the Corps became a most valuable asset."[97] Other methods had faltered—linesmen could not locate headquarters and runners were lost in the fog. Undoubtedly, W/T sets were effective for temporary military

[93] Steel, "Wireless Telegraphy," 8, 1 (October 1930): 92.
[94] WD, Report 1st Canadian Division, 1st Canadian Division Report on Amiens Operation Aug. 8th-20th Inclusive 1918, Appendix G, Signal Communications, August 1918, RG9 III-D-3, Folder 5059, File 968, LAC.
[95] Part 2 page 9, Reports on Wireless Communication During Amiens Offensive, General Report On Wireless Telegraph Communications in the Canadian Corps From February 1915 To December 1918, 22 April 1919, Control No. 19801226-284, Textual Record 58A 1 61.7, CWM MHRC.
[96] WD, 4th Canadian Divisional Signal Company, Communications, August 1918, LAC.
[97] Canadian Signal Service with Canadian Corps in the Field, RG9 III-D-2, Volume 4805, File 162, LAC.

communications when gaining the final objective.[98] The sets were appreciated when units occupied a new location before telephone cables and airline routes (wire mounted on short poles) were laid.[99]

Each divisional artillery headquarters exchanged CW-based messages with its brigades. Brig.-Maj. A. H. Bick, 1st Canadian Divisional Artillery, claimed CW wireless was the only dependable means of communication between mobile artillery units and artillery headquarters. CW operators were able to transmit information back to headquarters in under thirty minutes after securing a new position.[100] The 2nd Divisional Artillery reported that CW wireless sets were underutilised because the telephone lines held out. Later, the advance was too rapid to use the sets owing to their range limitations and need for dedicated transport.[101] The 4th Divisional Artillery's two replacement CW sets were successfully used between their headquarters and brigade headquarters. None of the Royal Field Artillery or the Australian Field Artillery seconded to the 4th Divisional Artillery was equipped with CW wireless.[102]

Four CW sets Mk. III performed flash spotting and forward observation work for the CCSS, which believed it was the first Allied formation to carry on flash spotting with CW wireless as the sole means of communication.[103] In twelve days, its three forward stations transmitted over 20,000 words where the distance from the OPs to the CCHA averaged 9,000 yards. CW wireless flash spotting was found to be superior to telephone flash spotting according to

[98] WD, 2nd Canadian Divisional Signal Company, August 1918, RG9 III-D-3, Volume 5005, File 691, LAC; and WD, 4th Canadian Divisional Signal Company, August 1918, LAC.

[99] The 4th Division's brigade and battalion sets were not properly adjusted, having been in use only a short time. See WD, 4th Canadian Division, Appendix 1, August 1918, RG9 III-D-3, Volume 4861, File 164, LAC.

[100] Arthur Bick, *The Diary of an Artillery Office: The 1st Canadian Divisional Artillery on the Western Front*, ed. Peter Bick (Toronto: Dundurn Press, 2011), 111.

[101] WD, GOC RA, Canadian Corps, 2nd Canadian Divisional Artillery, Report on Operations, August 1918, LAC.

[102] WD, GOC RA, Canadian Corps, 4th Canadian Divisional Artillery, Communications during Recent Operations, August 1918, LAC.

[103] Artillery Observation Section, 20 August 1918, RG9 III-C-1, Volume 3925, Folder 17, File 12, LAC; and WD, Canadian Corps Survey Section, August, 1918, RG9 III-D-3, Volume 5005, File 697, LAC.

Forde. Conversely, McNaughton claimed wireless was "a temporary expedient" to telephone flash spotting.[104]

Brig.-Gen. Raymond Brutinel's CIF infiltrated behind the German lines on 8 August.[105] Their CW set Mk. III, mounted in an armoured car, transmitted in clear on a wavelength of 1,450 metres and later 1,260 metres to the rear set at the Corps report centre.[106] This set eventually broke down and the Corps CW liaison station stepped in:

> It appeared that all wireless stations within the Army had been listening in to this traffic in order to obtain a first hand [*sic*] story of the conditions in the enemy back country, since the Independent Force had penetrated very deeply into the German lines and the wireless was their only means of communication.[107]

The Signal Troop, Canadian Cavalry Brigade followed the Canadian Corps into battle on 8 August 1918. Shell fire partially destroyed their spark set, forcing them back to Cavalry Corps headquarters to refit.[108] Wireless was in constant use since cable wagons could not keep up with the advancing cavalry.

Each Canadian division at Amiens was allotted a Mark IV Baggage tank, from the 4th Tank Brigade, fitted with CW sets and spares.[109] The tanks were unable to keep pace. Three eventually developed engine trouble. Regardless, communications were maintained.[110]

All infantry and artillery W/T tactical messaging in active operations should have been sent in clear. Flanking formations would have been aware of first-hand reports. Brig.-Gen. William Griesbach

[104] Report on Wireless Communications in the Canadian Corps Area, During the Offensive on the Amiens Front, August 8th-22nd, 1918, RG9 III-C-1, Volume 3923, Folder 10, File 6, LAC; and McNaughton, *Counter Battery Work*, 17, REF PAM UF 26 M356, CWM MHRC.

[105] The CIF operated from 8 to 27 August and from 1 to 4 September 1918. Brutinel's Brigade operated from 28 to 31 August and from 19 September onward.

[106] Report on Wireless Communications in the Canadian Corps Area, During the Offensive on the Amiens Front, August 8th-22nd, 1918, LAC.

[107] Steel, "Wireless Telegraphy," 8, 1 (October 1930): 91.

[108] WD, Signal Troop Canadian Cavalry Brigade, 8 August 1918, RG9 III-D-3, Volume 5006, File 695, LAC.

[109] A spark transmitter set was designed specifically for Mark I tanks in 1916. By fall 1917, CW had replaced spark.

[110] 4th Tank Brigade Report on Operations August 8th to 11th 1918, RG9 III-D-2, Volume 4798, File 102, LAC.

believed that after Zero hour all messages should be forwarded in clear whereas others, fearful of interception, did not want wireless-initiated operational messages.[111] Evidently, wireless traffic decreased when in clear messaging was forbidden. Wireless was invaluable to command centres, which required accurate information dissemination during continual advances and shifting of positions. Prompt transmission of battle conditions at this time outweighed the security risk.

The Second Battles of Arras comprised the Battle of the Scarpe (26-30 August) and the Battle of the Drocourt-Quéant Line (2-3 September). When the Canadians arrived in the area on 23 August, a loaned 1,500-watt Leyland Lorry set with 60-foot masts served as the main Canadian Corps directing station. A forward directing station was also erected. In the first two days, little spark wireless traffic transpired while brigades and divisions communicated over cable routes. The distance between battalion and brigade headquarters, as at Amiens, was too great for Loop set operation. A Wilson set served as the corps message station. Royal Garrison Artillery and Canadian personnel operated the CCHA's eight CW sets while spark sets were erected at 18-pounder batteries. Canadian operators worked with the CCSS on flash spotting and forward observation.[112]

During the Drocourt-Quéant battle, 1st and 4th Canadian Divisional headquarters' Wilson stations communicated with brigade BF sets. The narrow front and heavy traffic resulted in jamming. The directing stations were forced to move as the brigades forged ahead. From 26 August to 6 September Canadian divisional, brigade and artillery stations handled 1,107 wireless messages or 138 on average per day. By comparison, 500 daily despatch rider letters were relayed at divisional level and 2,170 at corps level.[113]

A 1st Canadian Division brigade alerted its parent formation via wireless of an impending enemy counterattack, while the forward lines were out of service. Loop sets and Power Buzzers were not used because a brigade signal officer believed "better results" were ensured

[111] Notes on Lessons Learned, RG9 III-C-3, Volume 4028, Folder 17, File 20, LAC.
[112] Report on Wireless Communication During the Operations at Arras, Aug. 26th-Sept. 10th, 1918, Canadian Corps, RG9 III-C-I, Volume 3923, Folder 11, File 3, LAC; and Steel, "Wireless Telegraphy," 8, 3 (April 1931): 389-92. Steel referred to the Canadian Corps Survey Section incorrectly as the Canadian Field Survey Section.
[113] Steel, "Wireless Telegraphy," 8, 3 (April 1931): 397-98; Priestley, *Work of R.E. in the European War,* 316; and Brig.-Gen. Norman Webber, 8 September 1918, RG9 III-C-5, Volume 4388, Folder 16, File 15, LAC.

by maintaining telephone lines.[114] The 3rd Canadian Division's Loop sets between the 7th Brigade and the 49th Battalion were maintained for emergencies only. On 2 September, a direct hit destroyed the 11th Brigade's set within five minutes of operation.[115] Fearing the 4th Brigade's wireless station assembled close to their headquarters would draw shell fire, the brigade major ordered the station moved to an open trench 100 yards away. The set become very damp from the rain. Consequently the brigade remained out of touch by wireless with the division all day. The damaged set with its weak signal was replaced the next day.[116]

On 4 September, the CIF reached the rear station over 9 miles away with a strong R9 signal.[117] The greatest distance between two CW sets Mk. III in the 2nd Canadian Divisional Artillery sector was 7 miles. The corps message station, the CCSS's headquarters and its four posts and Brutinel's CIF handled 1,890 wireless messages from 26 August to 10 September.[118] Brig.-Gen. William King, 4th Canadian Divisional Artillery commander, was exceedingly pleased with CW wireless, stating that he "would not go into action again without those sets. They transmitted and received very important messages when other means had failed."[119]

Unfortunately, transportation shook CW wireless equipment, necessitating complete overhauling, according to Forde's Arras operations observations. Inadequate wireless understanding among brigade staff meant that messages to division often went by wire or despatch rider. In open warfare, wireless served as auxiliary to wire

[114] Appendix G Report by 1st Canadian Divisional Signal Company, in 1st Canadian Report on Arras Operations Drocourt-Quéant Line, RG9 III-D-2, Volume 4793, File 44, LAC.

[115] Report on Wireless Communications During the Operations At Arras, Aug. 26th-Sept. 10th, 1918, 3rd and 4th Canadian Divisions, RG9 III-C-1, Volume 3923, Folder 11, File 3, LAC.

[116] Part 3, Report on Wireless Communications During the Operations At Arras, General Report On Wireless Telegraph Communications, CWM MHRC; and Captain Donald MacFarlane, RG9 III-C-1, Volume 3912, Folder 41, File 16, LAC.

[117] R1 very faint, R3 faint, R5 fair, R7 good and R9 strong. See *Handbook of Procedure, Wireless Telegraphy*, Appendix III, RG24-C-6-k, Volume 22022, LAC.

[118] Steel, "Wireless Telegraphy," 8, 3 (April 1931): 392-97.

[119] Report on Wireless Communications During the Operations At Arras, Aug. 26th-Sept. 10th, 1918, 4th Canadian Division, RG9 III-C-1, Volume 3923, Folder 11, File 3, LAC.

and despatch services.[120] In fact, Subramanian and Gooday argue the primary alternative to wire-based communication was signal despatch (runner, motorcycle, horseback and visual).[121] According to another report:

> Wireless is proving to be a most valuable, vital and reliable supplementary method of communication … So far C.W. Wireless has been used only for Artillery purposes and has proved entirely satisfactory, as it works splendidly over long ranges and gives little trouble from jambing [*sic*].[122]

On 27 September, Sergeant Charles Glaysher, 1st Canadian Divisional Signal Company, established a report centre east of the Canal du Nord shortly after the 5:20 a.m. assault by two Canadian divisions. His wireless aerials were shot down three times within thirty minutes.[123] The communications network from the division to 14th Battalion included BF sets between divisional and 3rd Brigade headquarters, a telephone line from 3rd Brigade to its report centre (Paviland Wood, west of the canal) and Loop sets between the report centre and 14th Battalion headquarters, east of the canal.[124] They resorted to Loop sets as lines had become over extended. The 4th Canadian Division successfully employed Loop sets between divisional headquarters and the divisional OP.[125] A wireless report claimed: "W/T communication was invaluable at intervals."[126] Once again, wireless was vital when telephonic and telegraphic networks failed or were congested.[127]

[120] Report on Wireless Communications During the Operations At Arras, Aug. 26th-Sept. 10th, 1918, 4th Canadian Division, LAC.
[121] Subramanian and Gooday, "British Telecommunications History in the First World War," 220.
[122] WD, 4th Canadian Divisional Signal Company, Communications, From the 1st to 5th September 1918, LAC.
[123] John Livesay, *Canada's Hundred Days: With the Canadian Corps from Amiens to Mons* (Toronto: Thomas Allen, 1919), 218.
[124] WD, Report on Communications Operations – Sept. 27th 1918, 3rd Canadian Infantry Brigade, September 1918, RG9 III-D-3, Volume 4878, File 229, LAC.
[125] WD, 4th Canadian Divisional Signal Company, October 1918, Report on Communications 4th Canadian Division 26-9-18 to 2-10-18, October 1918, LAC.
[126] Canal du Nord, Appendix G Report by 1st Canadian Signal Company, RG9 III-D-2, Volume 4797, File 45, LAC.
[127] Report by 1st Canadian Divisional Signal Company, C.E., Bourlon Wood Operations, RG9 III-C-5, Volume 4438, Folder 1, File 1, LAC.

After breaching the Hindenburg Line, the "main difficulty confronting Signals was that of keeping up with the advancing troops … [Signals] had to be adapted to the needs of a mobile force."[128] Telephone wires were practically non-existent during the advance averaging 2.7 miles per day. As the Canadian Corps drive came to a halt on 24 October at the Canal de l'Escaut, wired communication was essentially absent. Artillery brigades and the CCSS relied on CW wireless. A rear directing station controlled spark traffic with a powerful Telefunken transmitter. Late in October, the 1st Canadian Divisional Signal Company issued a report:

> As distances became too great, the use of wireless was somewhat lost, also there is the length of time necessary to code and decode. A remedy would be Sets of at least 10 miles range and if possible continuous wave instead of Spark, due to the closer tuning that is possible and hence eliminate of [*sic*] jamming, etc.[129]

The 4th Canadian Division launched its assault on Mont Houy and Valenciennes at 5:15 a.m. on 1 November. Seven CW groups were operating in the corps area, each on a different wavelength. A divisional OP was established on Mont Houy equipped with a telephone and a Loop set. Wireless messages were transmitted to 10th Canadian Brigade headquarters where they were relayed by a BF set to 4th Division headquarters at Denain. Hardly any wireless traffic was handled, although spark wireless between the division and its three brigades worked up to 15,000 yards; telephonic and telegraphic traffic prevailed.[130] Over 25,000 yards of line were in use in one infantry brigade's sector alone. A field artillery officer claimed "the telephone communications were never better."[131] However, McNaughton reported that some of the fire control system's main telephone lines were destroyed by shell fire.[132]

[128] Moir, *History of the Royal Canadian Corps of Signals,* 35.
[129] Lessons Learned – Douai-Valenciennes Advance, RG9 III-C-5, Volume 4438, Folder 1, File 1, LAC.
[130] WD, 4th Canadian Divisional Signal Company, Communications 4th Canadian Division 25-10-18 to 7-11-18, November 1918, LAC.
[131] Operations For Capture Of Valenciennes, 4th Canadian Divisional Artillery, RG9 III-C-1, Volume 3914, Folder 46, File 16, LAC.
[132] A. McNaughton, "The Capture of Valenciennes: A Study in Co-ordination," *Canadian Defence Quarterly* 10, 3 (April 1933): 292.

In the last week of the war, as the Canadians pursued the enemy rapidly across the border into Belgium, W/T was indispensable, especially between divisions and brigades. After the Armistice, during the march to the Rhine, CW wireless operated from army headquarters down to Canadian divisions and 1st Canadian Divisional brigades.[133] CW wireless was recommended for brigades back to GHQ to alleviate jamming and spark wireless for use in the most forward area.[134]

CONCLUSION

Commanders and staff officers were apprehensive of insecure wireless operations and sceptical of its capabilities. Accustomed to years of waging battle with wired communications, they could not relinquish their dependency on telephone and telegraph. Some unit commanders believed that good communication meant spoken communication. In the first two years of war, the lack of proper wireless organisation in Canadian formations and units meant knowledge of wireless capabilities from complicated, delicate sets were not inculcated, resulting in its underemployment. In 1916 Maj.-Gen. Richard Turner believed wireless was ineffective beyond brigade headquarters where shellfire destroyed aerials and masts. Senior signal officers stubbornly clung to the telephone habit, lacking confidence in wireless until mid-1917.[135] Before wireless was proven effective at Passchendaele, Lieut.-Gen. Arthur Currie considered it "subsidiary" to other communications media.[136] McNaughton's pigeon experiment and his preference for telephone flash spotting underlined senior officers' reservations. Nonetheless, the Canadian Corps did adapt to W/T developments throughout the First World War. Captain Basil Schonland considered Canadian Corps' wireless

[133] Moir, *History of the Royal Canadian Corps of Signals*, 40.
[134] Appendix G, General Report On Wireless Telegraph Communications, CWM MHRC.
[135] D. Campbell, "The Divisional Experience in the C.E.F.," 256; and Nalder, *The Royal Corps of Signals*, 218. Some telephone adherents became disenchanted upon learning of the security risk of overheard conversations.
[136] Bill Rawling, *Surviving Trench Warfare: Technology and the Canadian Corps, 1914-1918* (Toronto: University of Toronto Press, 1992), 135.

a model of efficiency.[137] Priestley noted that the "Canadian and Australian Corps, [were] often more hospitable to fresh departures in signalling than the Imperial troops."[138]

Early in 1918, wireless stations were not transmitting any traffic to each other.[139] Daily use would have made W/T more efficient and reliable, but signal security exigencies and obsessions throttled it.[140] The telephone—though not infallible with its 6-foot deep buried cables, danger zone and voice discipline—continued to dominate at operational and tactical levels of command and control.[141] During the Second Battles of Arras alone, the Canadian Corps expended 1,718 miles of cable.[142] In September, Brig.-Gen. Griesbach remarked: "it is obvious that we cannot continue to lay wires at the present reckless rate."[143] By mid-1918, W/T had become an essential signalling procedure. Nevertheless, telephone, telegraph and despatch services never relinquished their role as the most popular means of communication on the Western Front.[144] Unlike naval wireless, army wireless technology had not achieved adulthood. In reality, CW wireless transitioned into adolescence while spark wireless (its "golden age" was 1900 to 1915) began its obsolescence by 1919 and its use on all frequencies was forbidden in 1940.[145]

[137] Schonland, "W/T. R.E.," 7, 79 (October 1919): 396.
[138] Priestley, *Work of R.E. in the European War,* 226.
[139] Memo, 12 January 1918, RG9 III-C-3, Volume 4031, Folder 25, File 4, LAC.
[140] John Ferris, ed., *The British Army and Signals Intelligence During the First World War* (Gloucestershire: Alan Sutton for the Army Records Society, 1992), 6.
[141] Some 3,300 miles of field cable were dispensed weekly in 1918. See Boraston *Sir Douglas Haig's Despatches,* 335. The German field telephone network in 1917 stretched over 920,000 km (571,000 miles) on both fronts. See Jörn Leonhard, *Pandora's Box: A History of the First World War* (Cambridge, Massachusetts: Belknap Press, 2018), 518.
[142] Maj. Earnshaw, Use of Field Cables, 6 September, 1918, RG9 III-C-3, Volume 4057, Folder 35, File 6, LAC.
[143] Travers, *How the War was Won*, 151. However, some insisted that during mobile operations, telephone usage was more dependable due to "the scattered nature of the shell fire." See Major James Hahn, *The Intelligence Service within the Canadian Corps 1914-1918* (Toronto: MacMillan Company, 1930), 15.
[144] Cable was viewed as "the most valuable form of communication." See *SS 135 The Training and Employment of Divisions, 1918,* January 1918, 44, REF TECH U 510 G7 T7 1918, CWM MHRC.
[145] Aitken, *The Continuous Wave*, 59; and *Admiralty Handbook of Wireless Telegraphy Vol II: Wireless Telegraphy Theory* (London: HM Stationery Service, 1938), Section K, 1 and Section A, 1-2.

Canadian technical innovations were assimilated into the evolving signalling infrastructure. An interception-prevention method for the supposedly secure Fullerphone was developed in February 1918.[146] In August 1918 the CIF communicated over a CW set behind German lines. The Canadians were first to perform flash spotting with CW wireless as the only means of communication. In late October 1918, Steel built a receiver with seven separate tuning circuits with all outputs mixed in the telephone receiver, permitting the CW control station operator to listen to all seven CW stations simultaneously instead of listening briefly to one at a time. However, it was not only a matter of chasing the technology, but also organising, training and deploying wireless operators expert in Morse code and proficient in ciphering and interception techniques. Technical and organisational innovations produced a more efficient wireless network.

By war's end, battlefield communications were an amalgamation of traditional methods and technological advances. The 15th British Division, for instance, maintained flexible tactical communications in shell-swept areas with wireless, pigeons, runners and motorcyclists.[147] A combination of cable, wireless and motorcyclist despatch riders would produce a first-rate communications system in the Second World War.[148]

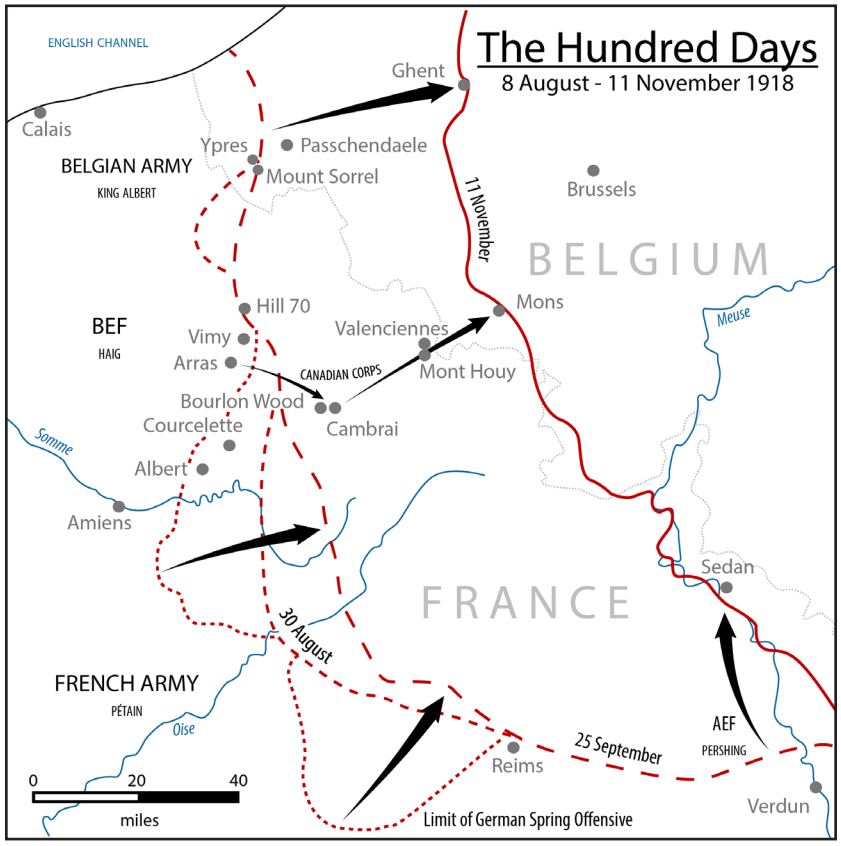
Once adapted to trench warfare, W/T provided temporary communication in emergency situations when the Signal Service's backbone of cable and airline routes had failed. In the Hundred Days campaign, after the advance had outrun forward line communication, of necessity wireless became a viable alternative, its relevance accelerated by open warfare.[149] The knowledge that an alternative was readily available was invaluable. Nevertheless, signal despatch remained the primary alternative to wire, especially when wireless traffic was enciphered. The Canadian Corps depended on W/T as

[146] The lightweight (18.5 lb) DC-driven Fullerphone was practically immune to interception by induction or earth leakage, thanks to very weak (microamps) Morse signals superimposed on the telephone lines.

[147] Lt.-Col. H. Crichton, Operations of 15th Division, 8 October, 1918, RG9 III-C-3, Volume 4028, Folder 17, File 20, LAC.

[148] Brian Hall, "Technological Adaptation in a Global Conflict: the British Army and Communications beyond the Western Front, 1914-1918," *Journal of Military History* 78, 1 (2014): fn 186.

[149] Nalder declared wireless in 1918 continued to be a practical stand-by method of communications and early in the Second World War. See Nalder, *The Royal Corps of Signals*, 150, 289.



an auxiliary system for surplus traffic during line congestion in battle conditions. Specifically, W/T was crucial while acting as the sole means of communication, as in the CIF's thrust into enemy territory and CCSS flash spotting. However, neither infantry nor artillery maintained an exclusive reliance on W/T as a tactical communication system in the forward area. Although W/T with its nascent capabilities was not a decisive war-winning technology that substantially enhanced battlefield communication on the Western Front, W/T operators "contributed in no small measure to the final victory."[150]

Had it been possible to issue CW sets along with suitable transportation to all arms of the service, transmitting in clear CW wireless with its minimal interference and longer ranges would have

[150] Schonland, "W/T. R.E.," 7, 76 (July 1919): 174.

rivalled wired communication in open warfare. Instantaneous two-way voice communication at the forward edge of battle would make its military debut in the next technological world war, when the portable bi-directional radio transceiver (walkie-talkie) was introduced.

APPENDIX A: SUBSTITUTION CIPHER USING KEYWORD

A keyword was used to assign the value of letters for a series of messages on a given cipher system. The W/T cipher keywords for the British Army's Field Cipher used by the Canadian Corps were updated every midnight. For example, the keyword for the 2nd Canadian Division on 11 March 1918 was **Asparagus** and the next day **Congratulate**.[151] For a simple substitution (plain) cipher using the keyword Congratulate, letter A is replaced by C, B by O, C by N, J by E, K by B, etc.

Plaintext alphabet:	ABCDEFGHIJKLMNOPQRSTUVWXYZ
Ciphertext alphabet:	**CONGRATULE**BDFHIJKMPQSVWXYZ

In 1918 experts using the British Field Cipher spent thirteen minutes enciphering, transmitting and deciphering a fourteen-word message.[152] By comparison, a forty-word telegram message sent in clear required 2.5 minutes to send.

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ABOUT THE AUTHOR

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[151] Lt.-Col. Ronald Alexander, W/T Cipher Keywords, 3 March 1918, RG9 III-C-4, Volume 4274, Folder 4, File 5, LAC.
[152] John Ferris, "The British Army and Signals Intelligence in the Field During the First World War," *Intelligence and National Security* 3, 4 (1988): 27.