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An Experiment inside an Experiment: Improvements in First World War Tank Wireless Communications

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ABSTRACT
During the First World War, new mobile fighting platforms, including aeroplanes and tanks, presented novel problems for an Army reliant on visual and line communication. Wireless was considered unwieldy, unreliable and non-secure. Unit War Diaries for Tank Signal Companies show only tentative and limited success for early experiments with wireless, with most researchers focusing on the small number of messages sent. This article re-evaluates this picture, balancing what were, indeed, limited achievements in message-carrying, against the rapid development of sound, highly effective radio procedures still recognisable today. Inverting the traditional focus on command decisions, the article strives to illuminate the achievements of those actually operating the equipment.

The First World War witnessed major advances in the development of battlefield technology, both tactical and in the sphere of communications. These were combined in the first tank units to take the field. The use of primitive wireless sets by early British tanks was described by one contemporary observer as 'an experiment inside an experiment'.[1]

The few modern researchers in this field have largely fallen into two camps. One group has downplayed the achievements of early wireless on the grounds of its primitive technology, technical limitations and paucity of messages sent, relative to those sent by other means, arguing that under the circumstances, the Army did the best it

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[1]Major R. E. Priestley, *The Signal Service in the European War of 1914 to 1918 (France)*, (Chatham: W & J Mackay & Co. Ltd., 1921), p. 245.

possibly could with wireless.[2] The other group holds that Continuous Wave (CW) wireless sets marked a paradigm shift in technology. One which could have shortened the war and which the British Army failed to exploit, due to a lack of insight and hidebound conservatism in the high command.[3]

This article takes an independent line, as it does not address attitudes within high command (from the top down), but focuses on the operators of the equipment (from the bottom up), crediting their growing confidence with CW technology and the rapid development of their procedures. It will argue that progress was driven more effectively by experience and experiments in the field than by direction or strategic decisions from above.

Analysing War Diaries from the 1 Tank Brigade Signal Company, this article will compare the Company's communication performance in its first two major engagements: the battle of Cambrai, in November 1917, and the German Spring Offensive of 1918. Compared to other Tank Brigade Signal Company War Diaries, that of the 1 Tank Brigade was more candid and comprehensive, perhaps a reflection of the personality of the Commanding Officer. Whether the unit was representative is a moot point. However, in September 1917, the entire establishment for Tank Corps Signals was 436 personnel in three Signal Companies.[4] By mid-1918 there were still only five Tank Brigade Signal Companies in total, many officers swapping between units, sharing best practices. Furthermore, the unit's account was fully supported by the War Diary of the 3 Tank Brigade Signal Company, which also served in both engagements.

The technology of wireless telegraphy involved messages transmitted using Morse Code, not voice. The place of wireless was not assured at this time and it contended with other communication methods including line telephone, the Dispatch Rider Service and the Army Pigeon Service. Far from being obsolete methods, these possessed complementary qualities and each made a major contribution. The

[2]Brian N. Hall, 'The Development of Tank Communications in the British Expeditionary Force, 1916- 1918', in Alaric Searle (Ed.), *Genesis, Employment, Aftermath: First World War Tanks and the New Warfare, 1900-1945,* (Solihull: Helion & Company, 2015), pp.161-162.

[3]Mike Bullock, Laurence A. Lyons, 'Response to Dr Brian N. Hall's Articles on British Wireless in the First World War', in *War in History*, Vol. 23, No. 2 (2016), pp. 230-250. Note: CW Wireless used transmitter valves to produce continuous waves. Energy was concentrated over a narrow frequency band, producing a signal with a stable amplitude and greater range.

[4]Priestley, *The Signal Service,* p. 252.

combination allowed the 1 Tank Brigade to enjoy a comfortable redundancy of communication means.

1 Tank Brigade Signal Company, Royal Engineers

The War Diary of the 1 Tank Brigade Signal Company records that the unit was authorised by the War Office in August 1917. Like all Signal units at this time, it was part of the Corps of Royal Engineers. The Unit Establishment consisted of four commissioned officers, one Warrant Officer, four Staff Sergeants, one Artificer and 92 Other Ranks, a total strength of 102. This number remained relatively stable over the next six months.[5] The unit's transport included 20 bicycles, 20 Triumph motorcycles, a box car and a lorry.

The Company was based near Arras in the sector run by the British Expeditionary Force's Third Army. Under its Commanding Officer, Captain E. F. Churchill, it operated four types of communication systems: Dispatch Rider Service, telephone, pigeons and wireless. Whereas the former two means predominated within camp, the latter two were intended for forward communications by tanks on the front line. Its first major operation was the battle of Cambrai in November 1917.

Captain Churchill, whose papers are held at the Imperial War Museum, had enlisted in 1914 at the Inns of Court OTC in Hertfordshire. Arriving on the Western Front in November 1915, he had already accumulated 13 months of experience as an Infantry Signal Officer with 32 Division and ten months as an Artillery Signal Officer with the 45 Heavy Artillery Group, Royal Garrison Artillery, before joining the Tank Corps in October 1917.[6]

Tank Communications during the Battle of Cambrai: A Comedy of Errors

Captain Churchill's account of the battle of Cambrai was disarmingly honest about the shortcomings of wireless. Indeed it reads like a comedy of administrative errors. These included: vital kit being missing; run down accumulators [7]; a wireless set being dismantled in error; and tanks unhelpfully departing before a set could be loaded.

Little prior training was recorded other than lectures on electricity and magnetism and some practical lessons in erecting antennas. The unit therefore went into battle with limited experience. Its intentions with wireless were modest. The apparatus and personnel for two Brigade Forward Stations would be dropped by Fighting Tanks at

[5]The UK National Archives (hereinafter TNA) WO 95/100/6, War Diary of 1st Tank Brigade Signal Company, August 1917, Appendix I, Brigade Tank Corps War Establishment, p. 5.

[6]E.F. Churchill papers at the Imperial War Museum (83/23/1).

[7]Re-chargeable low voltage lead acid batteries which powered valve heaters.

the Grand Ravine and Hindenburg Support Line, for working back to a Directing Station.

When establishing the Directing Station, the Army practice of 'adapt and overcome' was utilised: 'The 80 foot masts required for the Directing Station were unobtainable but makeshift masts were constructed out of telephone poles, which although cumbersome answered the purpose'.[8] As might be expected for a new technology, communications took up to one and a half days to establish. Communication was established with the first station at 1:30pm on 20 November and with the second at 3pm on 21 November.

> Several messages containing valuable information were received... During the evening of the 20th inst. the accumulators of the Directing Station ran down, but a message was transmitted to the station in the GRAND RAVINE by means of the Third Army Directing Station.[9]

Administrative problems were caused by confusion, acting on rumours, and by uncooperative attitudes from tank crews beset with problems and priorities of their own.

> The "G" Battalion Tank which took up the other Wireless set having been abandoned, the operators were told there was no further use for the set and it was accordingly dismantled. A third or reserve set was to be taken forward after Zero in a Gun Carrying Tank but although the operators made repeated enquiries they could not ascertain which was the tank allotted, and this set therefore remained at the Tankodrome.[10]

The battle of Cambrai saw the first mass use of tanks, and this demanded effective command and control. In all, 378 Fighting Tanks and 98 Support Tanks were deployed.[11] Each Battalion in the 1 Tank Brigade comprised 42 tanks, and wielded significant firepower.[12] Captain Churchill recorded several learning points from the battle. Transporting forward bulky accumulators was difficult (each wireless used

[8]TNA WO 95/100/6, WD 1st Tank Brigade Signal Company, Appendix I, Report on Communications During Operations, 20-23 November 1917, Captain E. F. Churchill, p. 23.
[9]TNA WO 95/100/6, WD 1st Tank Brigade Signal Company, Appendix I, pp. 22-23.
[10] Ibid., p. 23.
[11]Peter Simkins, Geoffrey Jukes and Michael Hickey, *The First World War*, (Oxford: Osprey Publishing Ltd., 2013), p. 144.
[12]Captain D. G. Browne, MC, *The Tank in Action*, (Edinburgh and London: William Blackwood and Sons, 1920), p. 268.

three, plus three charging) and all charging sets were fully occupied when wanted. The use of Fighting Tanks for logistical arrangements was unsatisfactory. 'In one case the apparatus had to be divided between two Tanks, one of which broke down and owing to the lack of room a 30 foot mast had to be carried outside. This fell off in transit and was lost.'[13] However, all this should not detract from the bravery of the signallers under fire:

> In the other case the Tank went into action with the first wave and was knocked out. The enemy being only 200 yards away and firing heavily on the Tank with machine guns, the Station could not be erected until they had been driven back. On account of the weight of these stations… it was impossible to move the apparatus and take advantage of cover for men and instruments. In one case the masts were erected under machine gun fire.[14]

More authoritative direction was clearly needed. The Wireless Officer, instead of being sent forward to one of the Stations, might have been better utilised checking that Tanks were allotted correctly and their Commanders knew exactly where to drop the Stations, and he later could have supervised re-supply and accumulator charging. Finally, the entire rationale of what information would be conveyed by the wireless links had not been fully thought out. The most valuable message sent during the battle was obtained by the Wireless Officer asking an Artillery Officer for a situation report to send. Captain Churchill's honesty in compiling these points must be admired. The shortcomings do not diminish the ingenious improvisation and bravery in what was to prove a highly valuable learning exercise.

The number of messages sent was small. In fact, it compares unfavourably with the number of messages sent by carrier pigeon. While both means were neglected after an initial surge of messages, carrier pigeons could probably be seen as more important than wireless during this battle. Captain Churchill wrote of the pigeons: 'fairly good results were obtained on the first day. Little use was made of the pigeons on the remaining days.'[15] The chief difficulty was the non-return of baskets from the tanks. In addition: 'On account of the fog and rain a few birds released late in the afternoon did not home until the next morning'.[16] This is in line with other generally favourable reports on the use of pigeons, with few birds being lost and average message delivery times being 10-20 minutes.[17]

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[13]TNA WO 95/100/6, Appendix I, Report on Communications During Operations, 20-23 November 1917, p. 25.
[14]Ibid., p. 25.
[15]Ibid., p. 22.
[16]Ibid., p. 24.
[17]Priestley, *The Signal Service,* pp. 89-92.

Communications Type	20 Nov	21 Nov	22 Nov	23 Nov
Wireless				
D Battalion Station	10	3	1	-
G Battalion Station	-	4	-	-
Pigeon				
Messages received Bapaume Loft	38	-	-	8
Messages received Vaulx-Vraucourt Loft	-	5	-	-

Table 1: Signals sent by 1 Tank Brigade - Cambrai, 20-23 November 1917

Figure 1: A pigeon being released from a British Mark V tank.[18]

Interestingly, the War Diary of the 3 Tank Brigade Signal Company gives a similar account of the battle of Cambrai. Also authorised by the War Office in August 1917, the unit was commanded by Acting Captain H. S. Carnegie and was at a similar level of inexperience. Its first action in the battle was to set up a Directing Station at Nurlu, the Diary stating: 'The set was of Wilson type, and the aerial put on a factory chimney about 50 feet high.'[19] The reference to the wireless set used is a valuable one, as it confirms that the sets this unit used at Cambrai were Wilson spark plug sets, which were more primitive than CW sets.

[18]Image from Imperial War Museum Collection – August 1918.
[19]TNA WO 95/107/12, WD 3rd Tank Brigade Signal Company, 18 November 1917.

The W/T Trench Set 130 Watt Wilson Transmitter, to give it its full name was used primarily for Division to Corps communication. Unlike the BF set, it had a fixed spark gap with a motor-driven, high-speed interrupter. The result was a greater number of sparks were produced per second giving a musical note at the headphones, thereby making the Morse signal easier to hear through interference. The transmitter had the same three fixed frequencies as the BF set and the higher power meant that the range was up to 9000 yards (approx. 8.3 km).[20] By elevating the antenna onto a factory chimney, the Directing Station was trying to maximise the range of its transmission and reception. The War Diary of the 1 Tank Brigade Signal Company does not explicitly mention the sets used at Cambrai, but it is highly likely that they also were Wilson sets.

As battle commenced, 'the Signal party and wireless in two tanks (Mark IV) moved up with the second wave and eventually reached the Rallying Point. One wireless set got into communication with back directing station, but signals got weak owing to distance - 12 miles - and running down of accumulators.'[21] It would seem the problem with the accumulators was a common theme in both units, which strongly suggests that the operators were not made aware of the issue until it happened. Meanwhile, expecting a wireless set with a range of 9000 yards to communicate effectively to a Directing Station 12 miles away was the fault of staff planners. To call it wishful thinking would be a gross understatement.

As for the 1 Tank Brigade Signal Company, the detailed communications instructions were to say the least sparse. They state, 'The Back Wireless Station of this Brigade will be situated at D 3 d and will be in telephonic communication through NURLU Exchange with Tank Brigade and Divisions. The Forward Wireless Station will be at Brigade Rallying Point in communication with Back Station.'[22] Operators searching for which frequencies to use and details of expected range, call signs, ciphers, link engineering codes, battery charging and so on would have searched in vain.

In his post-operation appraisal, Captain Carnegie noted that: 'For the 20th 50 birds were allotted to each battalion, but good results were not obtained, due to dull

[20]Keith R. Thrower, OBE, 'Army Radio Communication in the Great War', pp. 5-6, http://blogs.mhs.ox.ac.uk/innovatingincombat/files/2013/03/Army-radio-communication-in-the-Great-War_V2.pdf. Accessed 30 October 2020. The BF (British Field) set's three frequencies were: 857 kHz, 667 kHz and 545 kHz on wavelengths 350, 450 and 550 metres.
[21]TNA WO 95/107/12, WD 3rd Tank Brigade Signal Company, 20 November 1917.
[22]Ibid., Appendix III, Preliminary Instructions No 2 - Signal Communications - 3rd Brigade Tank Corps, 15 November 1917.

weather and bad treatment of the birds. The company reconnaissance officers and company commanders evidently did not need the birds issued to them as they did not use them, and pigeons were left in some cases, in dugouts &co until returned by police and salvage people.'[23]

Regarding wireless, Carnegie was slightly more positive: 'Two forward stations (Wilson Cabinet sets) were in female tanks which went forward after the second wave of attacking tanks and took up their position at the Brigade Rallying Point, getting into communication with the directing station at 10.30 a.m. on Z Day, after which several messages were sent through.' Signals were weak owing to the 12 miles between the Forward and Rear Directing Stations and the loss of battery power. A lot of messages were sent in clear (unencrypted) as the simple code used 'was not sufficient for stationary operations'.[24] This mysterious aside suggests that the codes may have been time-limited and the provision of the codes was insufficient. Nevertheless, 'the wireless station detached with No. 3 Tank Company got into communication back from MARCOING at 2.30 p.m. Z Day and sent many messages for 88th Infantry Brigade and other units. It was dismantled on 24th inst. when good telephone communication was obtainable to MARCOING.' Carnegie concluded: 'With a full code, and facilities for charging accumulators immediately prior to a battle, this method of communication should prove of the greatest use even with the present rather cumbrous apparatus.'[25]

Writing after the war, J. F. C. Fuller, a senior Tank Corps officer, historian and theorist of armoured warfare, painted the battle of Cambrai as a success for wireless communications: 'During this battle a much more complete system of signals was attempted, and wireless signalling proved invaluable in keeping in touch with rear headquarters and also in sending orders forward…'[26] Some modern researchers seem to have accepted Fuller's view at face value, perhaps overlooking some degree of subtlety in his argument:

> The most successful use of wireless in 1917 occurred at the battle of Cambrai… Most divisions reported very favourable results from the use of wireless… Clearly wireless was used on a far greater scale at Cambrai than in any previous British offensive of the war. Nevertheless, although the work done by wireless

[23]Ibid., Appendix IV, Signal Communications of 3rd Tank Brigade prior to and during Operations of 20 to 27 November 1917, Captain H. S. Carnegie.
[24]Ibid.
[25]TNA WO 95/107/12, Appendix IV, Signal Communications of 3rd Tank Brigade prior to and during Operations of 20 to 27 November 1917.
[26]J. F. C. Fuller, *Tanks in the Great War, 1914-1918*, (John Murray: 1920), Chapter XXIV. Tank Signalling Organisation, p. 180. http://allworldwars.com/Tanks-in-the-Great-War-1914-1918-by-John-Fuller.html. Accessed 26 November 2020.

> proved invaluable, it was widely acknowledged that a far greater proportion of messages could have been sent by this means, which suggests that the army was still not taking full advantage of it.[27]

The key word in Fuller's account was 'attempted', which seemingly was not the same thing as 'achieved'. Fuller's most perceptive comment was:

> The signalling experiences gained during the battle of Cambrai proved of great value. The most important being that it became apparent that it was next to useless to attempt to collect information from the front of the battle line. Even if this information could be collected, and it was most difficult to do so, it was so local and ephemeral in importance as to confuse rather than to illuminate those who received it.[28]

For the 1 and 3 Tank Brigade Signal Companies, wireless was not a success at Cambrai. It was not that more messages could have been sent by wireless, nor that the army failed to take advantage of a successful means of communication; there was little success to exploit, because the wireless procedures were either immature or non-existent and the personnel inexperienced and inadequately instructed. The main success was learning what not to do, as Fuller later hinted.

A Step Change: Wireless Performance in the 1918 Spring Offensive

The next major engagement for the 1 Tank Brigade Signal Company was a counter-attack against the German Spring Offensive of 1918. After Cambrai in 1917 wireless training had been intensified. In December 1917 and February 1918, three separate groups comprising a total of two officers and 45 soldiers travelled to the Tank Corps Wireless School in Fleury for training in CW Wireless Sets. 'Good progress had been made both in reference to Theoretical Knowledge of the instruments and also to procedure.'[29] This training appears to have been pivotal in what happened next.

On 20 March 1918, one day before the German Offensive, 'Wireless station opened. Call SAI working to FLEURY (SAR) for Tank Corps. Wavelength 1400 metres.'[30] This time the arrangements possessed a professional quality. Care was taken to ensure a supply of accumulators. Six High Tension (HT) emergency batteries were drawn (the wireless sets needed both types of power source). On 1 April 1918, revised codenames and Call-signs were issued:

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[27]Brian N. Hall, 'The British Army and Wireless Communication, 1896-1918', in *War in History,* Vol. 19, No. 3 (2012), pp. 307-308.
[28]Fuller, *Tanks in the Great War,* p. 181.
[29]TNA WO 95/100/6, WD 1st Tank Brigade Signal Company, 3 February 1918, p. 46.
[30]Ibid., 20 March 1918, p. 59; note, 'Call' would today be 'Call-sign'.

> Following Codenames and calls allotted for use in forward areas:
> 1st Brigade Tanks - CRIMSON - CGA
> 7th Battalion - RED - CGB
> 11th Battalion - WHITE - CGC
> 12th Battalion - BLUE – CGD[31]

Further signal arrangements were made on 16 April 1918 and in Electronic Warfare terms they have a remarkably modern ring:

> Attended conference called by AD Signals, Tank Corps, at 2nd Tank Brigade Headquarters… it was decided that special attention was to be paid to training operators in sending and receiving through jamming, and also having one man at each Station who could erect set and tune to correct Wavelength.[32]

Two wireless nets were specified, each working to a Directing Station, with an attempt at frequency separation between the two nets: 'The W/T System was divided into 2 groups A and B, each of three stations, one directing two. Group A was on Wavelength 695 metres and Group B on Wavelength 710 metres.'[33] On 9 April, it was recorded that six Standardised CW sets were drawn from the Wireless School. These were described as: 'CW Mark II as altered by Tank Corps Wireless Workshops. Standard Aerials 25 or 50 yards were used on 15 feet masts.'[34]

Continuous Wave Wireless sets were mainly used by forward artillery observers, due to their superior range to power ratio, and could be tuned to a particular frequency, unlike the more primitive "Trench Sets" used by the Infantry, but doing so required delicate handling and more technical ability from the user.[35]

It is not clear from the Diary whether this was the first issue to the unit of CW Wireless sets or whether it was the first issue of CW Mark II Wireless sets. The latter seems most likely, as the wavelengths referred to in March - of 14,000, 695 and 710 metres - suggest those used by CW sets. The first reference to training in CW sets

[31]TNA WO 95/100/6, WD 1st Tank Brigade Signal Company, 31 March 1918, p. 60; note, "D", "E" and "G" Battalions had been re-designated the 7th, 11th and 12th Battalions in January 1918.
[32]TNA WO 95/100/6, 16 April 1918, p 68; note, AD Signals was Assistant Director Signals, the Corps' senior Signal officer.
[33]Ibid., May 1918, Appendix VI, Report of Working of Wireless at 1st Tank Brigade, p. 83.
[34]Ibid.
[35]Priestley, *The Signal Service,* pp. 226-227. Also, Thrower, pp. 8-9.

was on 8 December 1917, when Lieutenant Mainprize and six Other Ranks were sent on a course, with further courses in February 1918. In December 1917, following successful trials, the Army had placed an order for 882 CW sets and they began to arrive in January 1918.[36] It is likely therefore that the unit had several months of experience using this technology before the German Spring Offensive.

In stark contrast to the muddle of Cambrai, comprehensive key information required for link engineering and operational procedure was provided. This included: arrangements for how to charge accumulators; technical data on how to tune the wireless sets; how to use the "Blinker" Wavemeter to pick up a wavelength; the Wavelength Matrix; a Call-sign Matrix; and a diagram showing the required links; commonly-used Address Groups; instructions on correct use of Voice Procedure; action on enemy jamming; and the use of codes and ciphers.[37]

The problems with accumulators were resolved during training. It was found that, when charged slowly using the ABC Charging Set, three accumulators could last for five days. Codes called 'X Numbers' were used for link engineering, examples being:

X150 - Your wavelength is too high
X151 - Your wavelength is too low
X152 - Your wavelength is now OK
X159 - Is my wavelength OK?[38]

Firm control was asserted over the wireless nets to ensure priority messages were not drowned out by routine messages. The Voice Procedure used included instructions on handling long messages: 'Directing Stations before sending "G" to an offer of a message will always listen in for 30 seconds in case any Station has a message of higher prefix or in case the Control Station is sending.'[39]

Network set-up followed a hierarchical pattern. The Directing Station and Control Station were set up first on 2 May 1918: 'No 1 W/T Directing Station established Cambligneul Exchange - working to 7th and 12th Battalion Stations, Brigade Control Station established on hill near Brigade HQ. Call allotted AXI.' [40]

[36]Priestley, *The Signal Service,* p. 227.
[37]Ibid., the entry for 6 October 1918 states that ALPHA code 5th Edition was used.
[38]TNA, WO 95/100/6, WD 1st Tank Brigade Signal Company, May 1918, Appendix X, Procedure for Wave Measurements, p. 88.
[39]Ibid., Appendix VIII, Notes on Wireless Station Working, 5 May 1918, p. 86.
[40]Ibid., 8 May 1918, p. 75.

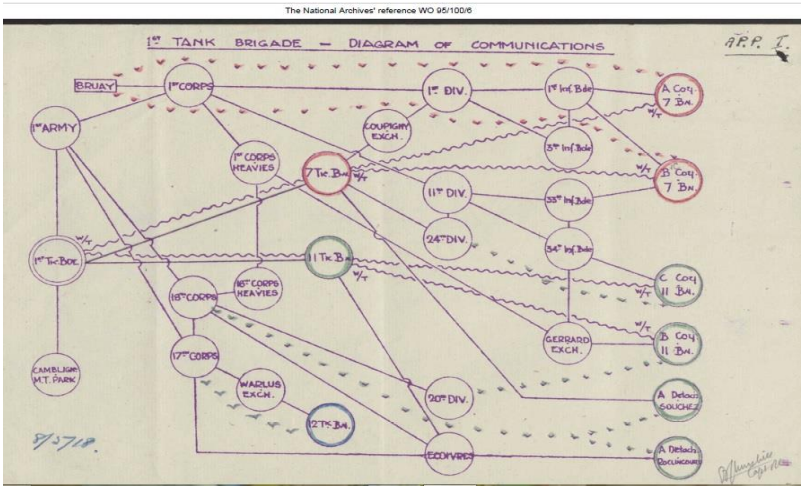

Figure 2: 1 Tank Brigade Diagram of Communications[41]

The Orders Group for the forthcoming operation occurred on 7 May 1918 where instructions were given to provide communication for companies of the 7 and 11 Battalions, who were deployed on the 1 and 18 Corps fronts. On 8 May, the arrangements all came together smoothly. It was reported that A Company of 7 Battalion established a wireless station and B and C Companies established another (Call-signs ASI and ATI), reporting to a Battalion HQ Station with Call-sign AVI. A Company of 7 Battalion established a wireless station and B and C Companies established another (Call-signs ASI and ATI), reporting to a Battalion HQ Station with Call-sign AVI. [42]

Enemy 'Direction Finding' notwithstanding, the Wireless Stations remained *in situ* for a long period, the only recorded move being on 29 May 1918 when A Company, 7 Battalion Wireless Station moved from Annequin Fosse to Enguingatte. The following day, most Wireless Stations closed down on the companies being withdrawn.

[41]May 1918, © Crown Copyright. Pigeons are denoted by bird symbols.
[42]TNA WO 95/100/6, WD 1st Tank Brigade Signal Company, 8 May 1918, p. 75.

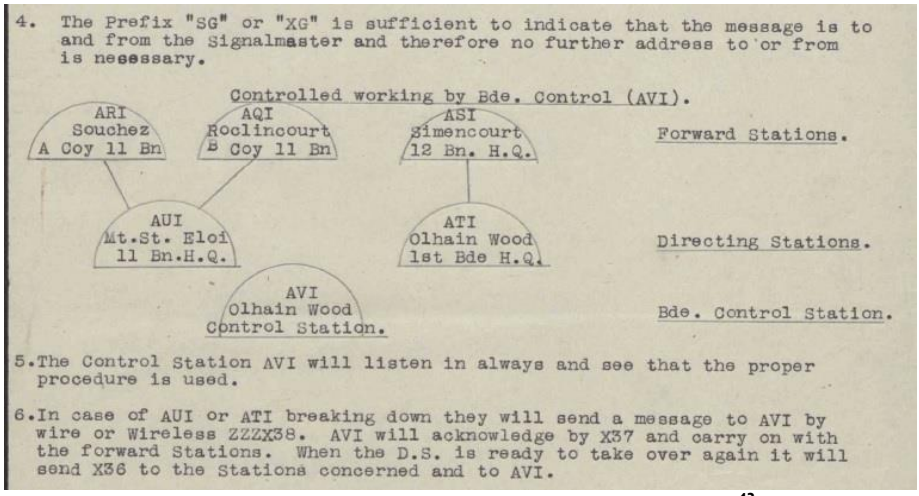

Figure 3: Excerpt from Notes on Wireless Station Working[43]

The experiences of the 1 Tank Brigade Signal Company during the German Spring Offensive were once again mirrored by those of the 3 Tank Brigade Signal Company. In December 1917, it also sent a small cadre of six wireless operators to the Tank Wireless School for training in the use of Continuous Wave sets after the issue of these sets to the unit at some time in the first quarter of 1918. The first mention of CW use was in late March, five days after the German attack. Albert was bombed and the telephone lines smashed beyond repair. As units tried to break contact with the enemy, the tanks had to move out and the established line Signal system collapsed. 'Operators brought instruments away from Southern Training Camp and destroyed stationery. Wireless communication established direct HQ Tanks, distance of 29 miles. Set a CW Mark III.'[44]

Major efforts were made by the unit to re-establish line communications, but wireless usage became much more important than it had been previously. By mid-April, a wireless station at Toutencourt, with four personnel, was working to a distance of 8,000 yards. Another, south east of Longueau, with five personnel, was working 16,000 yards to Brigade Headquarters. Here, at Mollien-au-Bois, was the Directing Station, with six personnel.

Frequency changes were being implemented at this time, another sign that CW wireless was in use: 'Wave length of wireless stations altered to 670 metres', then

[43]May 1918, © Crown Copyright.
[44]TNA, WO 95/107/12, WD 3rd Tank Brigade Signal Company, 26 March 1918.

'Wireless to work in groups of three stations, one group being on 670 metre wave length and one at 680 metre.'[45] This would have been unworkable for both groups, with severe mutual interference, as it did not allow sufficient frequency separation.

Clearly such lessons were being learned the hard way. Personnel were assigned to build links with the headquarters of neighbouring units: 'Wireless station and 4 men set up with New Zealand Division at BUS-LES-ARTOIS working 18,000 yards to Brigade.'[46] Finally, the rapid growth in wireless traffic in Spring 1918, both Allied and enemy, led to personnel being assigned to listen to transmissions to gather intelligence. On 10 May 1918, the 3 Tank Brigade Signal Company established a wireless intercepting station at Beauquesne.

In Fuller's account, he gave credit to one individual, a junior officer at the time, for the considerable progress in wireless training between early 1917 and the summer of 1918:

> In February 1917 Captain J. D. N. Molesworth, MC, was attached to the Heavy Branch to supervise the training in signalling. This officer remained with the Tank Corps until the end of the war, and in 1918 was promoted to the rank of Lieutenant-Colonel and appointed Assistant Director of Army Signals in 1918. Under his direction classes in signalling were at once started and considerable progress was made in the short time available before the battle of Arras was fought.[47]

A Further Experiment: Radio-Telephony Between Tanks and Aeroplanes

The 1 Tank Brigade War Diary makes an intriguing reference to a further experiment run at Noulette Wood from June to July 1918. Lieutenant Mainprize of the 1 Tank Brigade Signal Company and Lieutenant Moody of No. 22 Squadron, Royal Air Force (RAF) jointly conducted experiments in radio-telephony between tanks and aeroplanes. This was ground-breaking in two ways: the use of speech rather than Morse code over wireless and the intention to communicate between ground and air forces on the battlefield in real-time. The conveying of speech over wireless was only made possible by the use of CW sets. 'After certain experiments it was found possible to make an adapter for the CW Mark II set, by means of which speech could be transmitted at any Wavelength.'[48] This in itself was a major development, particularly as it allowed speech in both directions.

[45]TNA, WO 95/107/12, WD 3rd Tank Brigade Signal Company, 16-17 April 1918.
[46]Ibid., 22 April 1918.
[47]Fuller, *Tanks in the Great War,* p. 180.
[48]TNA WO-95-100-6_2, WD 1st Tank Brigade Signal Company, 22 June 1918, Appendix II, Experiments in Radio-Telephony, June 1918.

Three different tank-mounted antenna configurations were trialled, which were denoted as Type 1, 2 and 3. It was found: 'From an aeroplane, speech was received but was not very strong except when the aeroplane was diving or very close… From Tank to Tank on this aerial very good results at 300 yards… With aerials of Type 3, excellent signals were received from and also transmitted to an aeroplane, the observer remarking that the speech was quite as good as any he had received from a ground station, and quite loud and intelligible.'[49] Receiving audible speech from an aeroplane was particularly challenging, more so than for an aeroplane receiving speech from the ground. Major Prince, an early researcher in this area, made a telling point about the open cockpits of First World War aeroplanes: 'The transmitter must work in a region of intense noise, vibration and often violent air disturbances in which... the very muscles of the face can hardly retain their true shape under the varying wind pressures.'[50]

The diagram of the Type 3 antenna shows what today would be described as 'an inverted L antenna'. This was a potentially fruitful design in respect of communicating with aeroplanes, as it was a compromise antenna combining a small amount of groundwave signal (2 foot 6 inches being in vertical configuration) with a large amount of skywave signal (in horizontal configuration). Theoretically this would appear to be the most promising of the three antennas for the purpose under test.

'A demonstration of the results obtained was given on Friday, 5th July before the GOC, Tank Corps. The conclusion reached is that it is quite practicable to speak from Tank to Tank or from aeroplane to Tank, but further experiments are necessary to get the most efficient aerial to suit all requirements.'[51] Such an experiment at this early stage was over-ambitious, combining as it did multiple complicating factors, but was nevertheless impressive. While it is fair to say that: 'wireless telephony between tanks and between tanks and aeroplanes was at a very basic experimental stage when the war ended', the findings were concrete and practical, down to the type of antenna required and how it would be mounted on the tank.[52],

[49]Ibid.
[50]Major C. E. Prince, OBE, 'Wireless Telephony on Aeroplanes', *Journal of the IEE* (Institution of Electrical Engineers), Issue LVIII, 1920, p. 377.
[51]TNA WO-95-100-6_2, WD 1st Tank Brigade Signal Company, 22 June 1918, Appendix II, Experiments in Radio-Telephony, June 1918.
[52]Hall, 'The British Army and Wireless Communication, 1896-1918', p. 314.

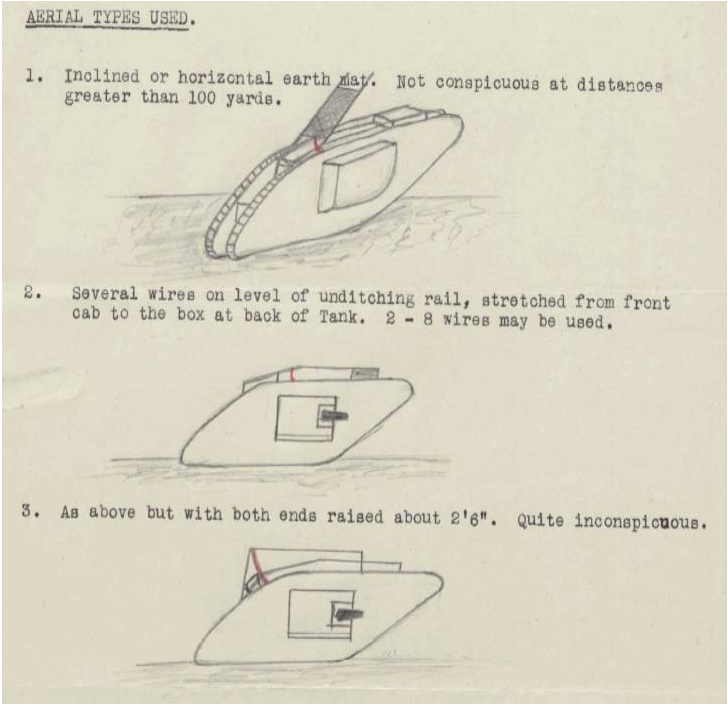

Figure 4: Diagram showing experimental antenna types.[53]

One researcher wrote of these trials: 'On 1 July, No. 8 squadron RAF was attached to the tank corps in order to conduct experiments with a view to finding the most efficient signalling method to facilitate co-operation between aircraft and tanks. The wireless-telephony trials were given up as a failure at the end of July but wireless telegraphy proved to be very successful.'[54]

The conclusion from the historian of a multi-volume history of the RAF was more nuanced:

[53]Experimental Work on Radio-Telephony, June 1918, © Crown Copyright.
[54]Andy Powell, 'The Use of wireless at the Battle of Amiens, 8 - 11 August 1918', Unpublished MA Thesis, 2013, available at: http://www.westernfrontassociation.com/world-war-i-articles/ma-dissertations/the-use-of-wireless-at-the-battle-of-amiens-8-11-august-1918/ . Accessed 15 December 2020.

> It was found that talk from the air could be heard inside a tank only under the most favourable conditions and so long as the aeroplane was within a quarter of a mile of the tank at a height not greater than 500 feet: it was accordingly decided that this means of communication was of no immediate practical use. At the end of July tests with wireless telegraphy proved successful, messages being clearly received in the tanks from aeroplanes which were 9,000 yards away and at 2,500 feet altitude. It was too late, however, to perfect the organization, equipment and methods of liaison, by which advantage could be taken of this success.[55]

Having promising results of no immediate practical use should not altogether be called a failure. Other researchers have been more positive, pointing out that: 'by the end of the war, Prince and his engineers had achieved air-to-ground, ground-to-air, and machine-to-machine wireless speech transmission. The Royal Air Force had equipped 600 planes with continuous-wave voice radio and set up 1,000 ground stations with 18,000 wireless operators'.[56]

Conclusions

For the 1 Tank Brigade Signal Company, the average daily traffic for May 1918 was 12 wireless messages. This must, however, be set against '277 DRL (Dispatch Rider Letter Service) packets, 249 Messages (which included pigeon and line messages) and 299 'Phone Calls' daily, thus proving that wireless occupied only a small niche in the overall communications picture.[57] Tank wireless at this time was limited in two ways: it involved telegraphy rather than voice, although promising voice experiments were only two months away; and wireless was only carried by tanks, and was dismounted for use.[58]

'Very satisfactory results' were reported for the 50 yard antennas used at the Directing Stations. The performance of the 25 yard antennas used by the Forward Stations was mixed. Even so, 'the average range was 6 ½ miles, but in one case was 12 miles'. [59] For comparison, "Trench" sets had a range of 4000 yards. Signal strength

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[55]Henry Albert Jones, *The War in the Air; being the story of the part played in the Great War by the Royal Air Force* (Oxford: Clarendon Press, 1922), volume VI, pp. 464-465.
[56]Allison Marsh, https://spectrum.ieee.org/tech-history/dawn-of-electronics/in-world-war-i-british-biplanes-had-wireless-phones-in-cockpit. Accessed 15 December 2020.
[57]TNA WO 95/100/6, WD 1st Tank Brigade Signal Company, Appendix VIII, Notes on Wireless Station Working, 5 May 1918, p. 77.
[58]Experimental work was later done to copy the French Tank Corps in mounting wireless sets in tanks.
[59]TNA WO 95/100/6, WD 1st Tank Brigade Signal Company, May 1918, Appendix VI, Report of Working of Wireless at 1st Tank Brigade, p. 83.

was 'R9 both ways'.[60] Importantly, messages were being encrypted, not sent in clear text.

There is little doubt that CW wireless was a conspicuous improvement in technology relative to spark gap wireless sets, directly paving the way for voice telephony. There is also evidence that some Tank Corps personnel saw the General Headquarters (GHQ) as obstructive. For example, one decorated tank commander wrote in his memoirs, 'The Corps was consistently disregarded in official despatches. It was hampered at every turn by the conservative outlook of senior officers.'[61] However, in contrast to the development of this argument by Mike Bullock and Laurence Lyons, this article considers the success of the technology ultimately rested in the hands of junior officers like Captains Churchill and Carnegie and their technical experts. Whatever scepticism about tanks or wireless existed within high command, this does not seem to have been shared at the very top: 'Haig had faults but opposition to new technology was not one of them.'[62]

The superiority of CW wireless over spark gap sets, although clear with hindsight, was not clear in 1918. The attitude of the Royal Engineers Signal Service was that both types of technology – 'half-brothers' – had an assured place in the Army. Each had advantages and disadvantages. Indeed in one particular detail, CW wireless was singularly ill-suited to use with or inside tanks. The sets were extremely delicate instruments, not easy to carry 'in the interior of a wildly-gyrating machine whose chief title to fame is a disregard for obstacles and unevennesses in its path.'[63]

This research endorses Brian Hall's conclusion that: 'the BEF's tank communications system in the summer and autumn of 1918 was certainly much more flexible, robust and sophisticated than it had been in 1916.'[64] Hall's research rigorously demonstrates that, regarding tank-to-tank communication: 'the limitations of the communications technology at the time, combined with the inadequacies of the tanks themselves, continued to impose profound restrictions on the tactical and operational effectiveness of tanks in battle.'[65]

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[60]The 'R' (Readability) Scale ran from 'R1' (weakest) to 'R9' (strongest), each step being 4 decibels.
[61]Browne, *The Tank in Action* p. 7.
[62]J.P. Harris, *Men Ideas and Tanks: British Military Thought and Armoured Forces, 1903-1939*, (Manchester: MUP, 1995), p. 56.
[63]Priestley, *The Signal Service,* p. 246.
[64]Hall, 'The Development of Tank Communications in the British Expeditionary Force, 1916-1918', pp.161-162.
[65]Ibid.

However, this article is more commendatory than Hall in its assessment of evidence of the promising early developments in tank-to-aeroplane communication and the considerable practical progress made with CW Wireless in tank-to-headquarters communication. The latter, high-level, signals merit more attention from researchers, who tend to focus on low-level signals, because they are more interesting and due to their obvious tactical importance.

Fuller divided the system of field signalling into 'local' (between tanks and tanks and tanks and infantry) and 'distant' (between tanks and unit headquarters, infantry and artillery observation posts, balloons and aeroplanes). Significantly, Fuller's appreciation of the importance of signals was geared towards the operational level and related more to 'distant' signalling:

> The importance of signalling in a formation such as the Tank Corps cannot be over-estimated, and this importance will increase as more rapid-moving machines are introduced, for, unless messages can be transmitted backwards and forwards without delay, many favourable opportunities for action, especially the action of reserves, will be lost. Making the most of time is the basis of all success, and this cannot be accomplished unless the commander is in the closest touch with his fighting and administrative troops and departments.[66]

With respect to high-level signals, the spark gap technology used at Cambrai had been superseded by CW Wireless Mark II and Mark III, with hindsight, a significant step forward. Of equal importance was the improvement between the amateurish, desultory wireless usage in November 1917 and the well-organised, competent usage of Spring 1918. This technical and procedural professionalisation, over a period of only seven months, was an impressive achievement.

The debate about tank communications represents in microcosm the larger debate about the utility of tanks, which again falls into two camps. One argues that First World War tanks were primitive, cumbersome and of limited value: 'Both mechanically and humanly, the tank of 1918 was not a war-winning weapon.'[67] The other sees tanks as possessing great potential but as having been held back by traditionalists who favoured the infantry and cavalry, 'Tanks could have provided (and did provide at Amiens) the

[66]Fuller, *Tanks in the Great War,* p. 183.
[67]John Terraine, *To Win A War: 1918 The Year of Victory*, (London: Cassell, 2008), p. 117.

centre-piece and breakthrough weapon… All of this required a change of attitude at GHQ.'[68]

While this article does not address this wider debate the lessons drawn here from tank communications seem equally applicable. The difference between the Mark I tank used on the Somme in 1916 and the Mark IVs and Vs which took the field from summer 1917 to the end of 1918 was as much a qualitative advance as that affecting the wireless sets. For example, the Mark I tank had poor observation, no silencer on the engine, open exhausts and was highly vulnerable to explosions, with two 25 gallon tanks of petrol in the front. Four of the crew of eight were drivers. The Mark IV still had four drivers, but a 70 gallon armoured petrol tank low down in the rear while the Mark V required only one driver.

> Although similar in appearance to earlier models the Mark V was a much better tank, more powerful and easier to drive. It was equipped with the new Ricardo six-cylinder engine and Wilson's epicyclic steering system which meant that one man could handle all the controls, compared with four in the Mark IV.[69]

It also had 'a four-speed gear-box, immediately in rear of which was the reverse gear, providing "reverse" on all speeds… Further, the engine was completely enclosed in a sheet-iron casing, from which the hot foul air was exhausted through the roof of the tank by means of a Keith fan.'[70]

As the designs radically improved, and as technology was refined, negative attitudes and the motivations of elements within the high command seem to have been bypassed by events. But the technology was only part of the picture. It was the practical actions, the developing procedures and the growing confidence of the men actually operating and directing the vehicles that provided the unstoppable momentum for tanks to be successful.

The position outlined here is that technical and procedural progress in Tank Corps wireless communications - and perhaps in the Tank Corps generally - came from the bottom-up - from the operators, and it was both rapid and far-reaching. The key

[68]Tim Travers, 'Could the Tanks of 1918 Have Been War-Winners for the British Expeditionary Force?', *Journal of Contemporary History*, Vol. 27, No. 3 (Jul., 1992), p. 402.

[69]The Tank Museum, Bovington, website, https://tankmuseum.org/tank-nuts/tank-collection/mark-v/ Accessed 29 November 2020. This contains useful videos, presented by David Fletcher, MBE, about the Mark I, II, III, IV and V tanks on display at Bovington.

[70]Fuller, *Tanks in the Great War,* pp. 42-43.

importance of practical experimentation in the field did not escape the notice of the founding theorist of the Tank, Sir Ernest Swinton, who from an early stage had fought for 'some method whereby Tanks could signal back towards their starting-point... The obvious way was by wireless…'[71]

> At the last moment, GHQ ruled that the Tanks were not to be fitted with wireless - so far as I remember - because of the possibility of "interference" with existing installations… They were condemned to go forth to battle having eyes (of a sort) to see, and ears to hear, but no voice with which to speak. Some months later, as a result of experience in the field, the possible advantages of wireless communication were realised, and fresh experiments in this direction had to be made.[72]

[71]Major General Sir Ernest D. Swinton, *Eyewitness - Being Personal Reminiscences of Certain Phases of the Great War, Including the Genesis of the Tank*, (New York: Doubleday, Doran & Company, Inc., 1933), pp. 206-207.
[72]Ibid., p. 226.