What role has technology played in warfare 1789 to 1945?

A definition of technology is "The application of scientific knowledge to the practical aims of human life or, as it is sometimes phrased, to the change and manipulation of the human environment".[1] Technology is the scientific advancement of basic human capabilities, for humans to see, speak, hear, move and think, to operate better and faster and over greater distances than humanly possible. Technology can drive benefits for all mankind such as the internet, medicine or transportation; but in warfare, technology at its most basic is for killing more people, to win the battles that will win wars. In warfare, technology is not just about improved weapons, it includes weapons systems of hardware and human software to support front line actions such as communications and logistics and these have led to the development of non-combat military roles employing management techniques. Social advancements and civil technology have also been adopted and adapted for military use such as railways, communications, education and medicine.

There is specific technology developed for military use by an arms industry. Driven by the Industrial revolution, there has been a recorded arms industry in Britain since 1796, where industrialists such as Samuel Galton in Birmingham were manufacturing weapons[2]. There are examples of conflict being used as live firing tests for weapons; including the dropping of the atomic bombs or the sinking of the Belgrano as weapons have become products of the arms industry.

War drives technological advancement and weaponry has developed constantly; from the blade to the bullet to the rocket but it may have reached its conclusion when a weapon can wipe out a city and hundreds of thousands of people in seconds; and is so effective it may never be used again. The argument over whether nuclear arms are a weapon or deterrent is for another day. Advancement has been particularly rapid in the twentieth century and there are plenty of examples such as radio communications, radar, sonar, tanks or aeroplanes. Nuclear weapons have not replaced guns and rockets and boots on the ground, but continuous technologies have been developed as mankind moves from the computer age into the Artificial Intelligence age where drones now fight the enemy and keep soldiers safe. Some technologies have revolutionised warfare with an immediate step change, such as the introduction of the tank in World War One, whilst some have had a slower trajectory, such as small arms, but they all contribute to the same objective; to maximise killing potential against an enemy.

This essay is not going to be a list of every technological advancement over more than one hundred and fifty years but it will use examples to illustrate the role of some different technologies to influencing the outcome of conflict.

The invention of Gunpowder by either the Chinese, or the Arabs, in the 9th century, and available in Europe as early as the 13th century was a revolution which ultimately changed the battle from cavalry charge to field artillery and siege. Hand-to-hand fighting with blades and sharp points was still required even though killing was available over greater distances with lead shots and bullets. The Industrial Revolution from the late eighteenth to mid nineteenth centuries drove huge British economic growth, changing Britain to a city-based manufacturing economy. This brought new techniques, processes and mass production, ideal for the military to employ increasingly more deadly weapons. For example, better casting and milling processes allowed cannons to be manufactured more quickly with more accurate bores to give greater accuracy and in greater numbers. Small arms could be mass produced for the ordinary soldier which evolved, for example, from the musket at Waterloo, to the breach loading bolt action rifle to the magazine loaded rifle of World War Two. As these technologies became widely available, more sophisticated weapons were needed to provide even greater killing power. The technology of the Gatling gun of the American Civil War developed into the Lewis gun and ultimately into the handheld machine gun. The consequences of these technologies in World War One was not just a better killing capacity, but the machine gun gave defence the upper hand with a greater field of fire, which led to the stagnation of trench warfare, with the empty battlefields of No Man's Land. If the role of this technology was to kill more people than ever before; the first day of the Somme with 56,000 British casualties is proof of success. World War One was said to be the

[1] Britannica.com
[2] Historyextra.com, How war sparked the Industrial Revolution

culmination of the industrial age[3]. The typical soldier of World War One carried his own gun, the design of which had evolved for greater violence during the nineteenth and early twentieth centuries; armies were organisations co-ordinating the actions of men, all weapons were individual[4].

Technologies do not develop in isolation; they can be complementary. Before the invention of the telescope in in early seventeenth century, messages were delivered by horseback at best, or over short distances only as far as the human eye could see. The telescope extended the power of human vison to improve these rudimentary communications typically by letter or flag signals.

Semaphore was developed by the Chappe telegraph in France in 1794 with communicating semaphore towers, capable of transmitting multiple massages up to 400 kilometres per day but its disadvantages were bad weather visibility, and it only took one tower to be out of use for the whole system to break down. This was an early example of a system created for civil use adapted for military use. This military use needed a management system for the standardisation of procedures and orders for it to be efficient. This was the introduction of non-combatants in management roles for military use.

From the 1830's the invention of the Electro Magnetic Telegraph particularly when used with Morse code in the 1840's increased the range and speed of communication transmitting messages quickly by wire through a system of relay stations. The expanding steam railway system and electric technology, both products of the Industrial Revolution, developed simultaneously; the telegraph and the railways were a great technological combination. Civil railway technology expanded a network across Europe, gauges were standardised, and systems with increased integration, sophistication and wider usage had to be managed, such as timetables and track management, these led to the end of local time and the synchronisation of clocks nationally and globally. Between 1870 and 1914 track mileage tripled in Europe to 180k miles, particularly in Germany and Russia. The military potential of these civil technologies was quickly recognised.

The railways were used not just for moving men and weapons to the front but for hardware from production to distribution. In the 1850's, France built a railway line to Sebastopol in the Crimean war and in 1859 it mobilised 250k men into Italy by train; but it was most notably Prussia who utilised a more efficiently manged railway system to allow fast mobilisation and concentration of troops. In 1866, Prussia prevailed against Austria, who could not mobilise quickly enough and in the Franco Prussian war of 1870, Prussia again quickly assembled an army of 462k to take the offensive before France with an inferior railway system could mobilise a defence.

By the start of World War one in 1914 railway technology was central to strategic planning allowing armies to be moved faster than before. The German Schlieffen Plan depended on speed of movement and rapid attack using the railway system to encircle Paris through Belgium and France and then move against Russia by rail. AJP Taylor argued that the start of World War One was dependant on train timetables, to get millions of men mobilised[5]. The railways became so central to the military that a Railway Department was added to the General Staffs across Europe and there was huge integration of civil and military resources. These required non-military experts with scientific and mathematical knowledge in high positions in the military and an early example of human software, and railway hardware integration. The railways allowed huge German troop mobilisation and weapons movements across occupied Europe in World War Two and ultimately allowed armies to stay in the field for as long as they could be supplied[6].

The early twentieth century introduced radio and the internal combustion engine to the military, and both of these had to be integrated into larger systems. Motor vehicles in the army gave greater flexibility than the railways but they needed a support system for fuel, spares, repairs and maintenance. Radio without the restriction of wires had many applications but it revolutionised two-way communication between the High Command and the battlefield and this was an important technological step forward for World War Two. An example of how the role of radio

[3] Podcast, The National Archive, Railways and the mobilisation for war in 1914
[4] Encyclopedia.com
[5] Podcast, The National Archive, Railways and the mobilisation for war in 1914
[6] Podcast, The National Archive, Railways and the mobilisation for war in 1914

gave an advantage was in the first North Africa campaign when British forces who could only receive messages from HQ were at a tactical disadvantage and were defeated by Rommel's German tanks equipped with two-way radio. In the Battle of the Atlantic, German U-Boats communicated by wireless using Enigma machines. The radio traffic could be monitored by Britain but not understood. It was decoded by the Ultra system at Bletchley Park. The team at Bletchley Park devised automatic machinery to help with decryption, culminating in the development of Colossus, the world's first programmable computer. Bletchley Park was a military installation, but the decoding was carried out by civilians and Colossus was developed by the British Post Office; an important example of Civil technology being used by the military. Ultra technology analysed information faster and in greater quantity than humanly possible, probably shortened the war by two to four years and was one of the technologies that ensured an Allied victory[7].

During World War One a development using radio technology was the introduction of an underwater listening device. The radio microphone was adapted into a hydrophone to listen for the sound of a submarine from a surface vessel. However, this had a limited success due to disturbance by sounds other than the submarine it was tracking, such as noises made by sea conditions and the actual ship carrying the hydrophones. By World War Two this crude technology was developed into ASDIC (Anti-Submarine Detection Committee) where sound pulses from a surface ship were transmitted and when the sound pulse struck a submerged German U Boat the pulse returned and the speed, bearing and depth of the U Boat could be calculated so that eventually the ship could attack the U Boat with depth charges. Again, its effectiveness was not foolproof for a single ship, working alone. The ship had to pass directly over the U Boat to launch its depth charges but at the last moment it lost contact and the depth charge was fired blind, which could allow the U Boat to escape. This was remedied with the introduction of the convoy system and new anti-submarine tactics. When several ASDIC fitted ships worked together, they could fill the acoustic blind spot and with the introduction of forward-launched weapons such as the Hedgehog, where the charges were launched in front of the chasing ships whilst they were still in ASDIIC contact, better accuracy was achieved and if air support was available submarine hunting was even more effective. Ultimately, this system defeated the German U Boats and was one of the turning points in World War Two. The weapon that allowed humans to hear under water was a technological step forward even if it was not completely successful on its own but it overcame its shortcomings when it was included in a joined-up system when it was much more effective[8]. ASDIC was purely military technology, but it was developed further into SONAR which is now available commercially for ships and boats virtually all sizes.

A fighting "man" cannot function without food and ammunition and machines cannot work without fuel, maintenance and repairs. At the same time, weapons have evolved from just personal weapons into weapons systems. Weapons systems can be tactical such as ships working together with ASDIC or operational such logistics. Fulfilling these non-combat roles has created systems of supporting technologies such as logistical and medical corps to ensure maximum efficiency for the fighting "man". These technologies expanded military bureaucracies using management techniques and when combined with advances in printing, have allowed armies to become more professional. Bureaucratic functions essential to the smooth running of a fighting force such as rotas, reports, records, and communication of orders were developed. The invention of the typewriter made it one of the most important pieces of equipment in World War One.

Additionally, printing allowed the creation of military manuals for consistent methods for the management of a fighting force in times of war or peace. Significantly, the standard works of military strategists such as Clausewitz and Jomini were available across the world and in the new military training schools such as the Berlin Kriegsakademie and the US West Point.

The development of systems integrated across the population increased the scale of war, to Total War. Mobilisation could now be in millions rather than thousands and the non-military population could now be

[7] britannica.com
[8] Llewellyn Jones, Malcolm, The Royal Navy and Anti-Submarine warfare 1917 to 49, Taylor and Francis, 2006, chapter 3

employed using the advances in administration, communications, transportation and public health to create a joined-up approach.

Technology and its development is expensive and the Industrial Revolution allowed the big economies to exploit economies of scale to enable the creation of big battalions backed up by big GNP[9]. A superior technology will usually defeat an inferior one. To this extent, it is understandable that victory in World War Two did not go to the side whose soldiers fought the hardest, or that came up with the most brilliant operational schemes. Rather, those belligerents gained the upper hand whose administrators, scientists, and managers developed the means by which to set up gigantic technological systems and run them as efficiently as possible[10].

In principle, technology will never stop. There are some examples where technology has stalled such as supersonic civil aviation with the decommissioning of Concorde, but development will be continuous because of human ingenuity and its quest for knowledge and constant improvement; pushing the boundaries of existing knowledge to create new technologies, such as the transformation of analogue to digital computer processing. In warfare, as these technologies are weaponised and when they become available to both sides in conflict other developments are sought to gain an advantage; technology has the potential to revolutionise warfare to maximise violence to win the conflict. At its most basic the role of technology in warfare is to improve human capabilities; to see further than the naked eye, listen under water, communicate over long distances, move faster than a galloping horse and solve problems accurately and quickly and to keep men fighting and killing.

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[9] Van Creveld, Martin, Technology and War, The Free Press, 1989, Page 158
[10] IBID, Page 158