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EVOLUTION OF MILITARY TECHNOLOGY FROM EARLY 19TH TO LATE 20TH CENTURY: ITS IMPACT ON WARFARE

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Foreword

Strategic Vision Institute (SVI), Islamabad has initiated a new project entitled 'SVI Monograph Series' which will cover specific subjects related to strategic and security issues of contemporary relevance and importance as ready reckoners for scholars and researchers both in academia and in the think tanks community to stimulate their interest in further research, analyses, and writings on these subjects. Such monographs would be published periodically in addition to the existing SVI Journal and other publications and hopefully would provide a valuable collection of quality reading and research material. This maiden publication is a kind of trend-setter and would hopefully be followed by many such publications in future.

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Abstract

The relationship between technology and warfare is as old as the history of war, epitomised by Bernard and Fawn M. Brodie's classic 'From Crossbows to the Hydrogen Bomb.' Technology has continued to evolve through the ages, with it the character, scope and canvas of warfare. Understanding this phenomenon is important not only for an informed analysis of wars of yester years but to anticipate and comprehend the changes that are likely to be imbued in the nature of future wars and armed conflicts by emerging technologies. Some of these emerging technologies have truly epoch-making potential. The study of such experiences in the past is important because it tells us that while such episodes in the past caused momentary anxieties solutions were soon found to manage their impact, and their anti-dotes were also developed before long. In this context, this historical survey is important to lay the foundation for further studies about emerging technologies' potentialities, complexities and likely impact. As such, a glimpse of some of the modern technologies has been provided, which will be covered in much greater detail in similar monographs.

Preamble:

History of Warfare bears witness to the fact that technology in general and military technology, in particular, has had a profound effect on the scope, scale and way the wars have been fought by impacting the developments at both tactical and strategic levels. The pace of technological developments has for the most part been evolutionary in nature, with the except for a few epoch-making developments that brought about revolutionary changes in the ways war was contemplated and fought. Up to 1500 AD, the process of innovation in the designs of weapons and other implements of war only brought about marginal changes and many of the devices in service at the end of this period were not very different from those in use in the previous centuries.[i] However, the period between 1500-1830 AD saw significant developments, first, by the replacement of wood by metal as the basic building material for military technology which was followed by a shift towards steel in the period between 1830-1945. But the landmark development in this particular segment of history was the introduction of the steam-powered railways and electric telegraph in 1830, which profoundly affected the conduct of war and strategy. In the post-1945 era, steel has been gradually replaced by alloys, ceramics, synthetic and composite materials. The modern age has seen an increasing movement towards automatic and, more recently autonomous weapon systems.

It is difficult to trace all the developments that have taken place in the realm of military as well as civilian technology with military applications since the beginning of recorded history within the scope of one study. The second challenge is the choice of an appropriate analytical model. In this context, two models are available to follow. First, the model used by Barry Buzan,[ii] in which he has analysed the changes at both tactical and strategic levels which have taken place in Land, Air and Sea warfare in five specific areas where technological changes have taken effect i.e., Firepower, Mobility, Protection, Communications and Intelligence. However, this framework is difficult because there is not much scope for a detailed study of the tactical and strategic implications of technological innovations pertaining to individual services. The other model is adopted by scholars such as Martin Von Creveld who have analysed the impact of changes in the above-mentioned areas of military technology on Land, Air and Sea warfare. The disadvantage of this approach is that there is bound to be a repetition of certain aspects which are common to all three services. However, it allows enough room for an elaborate discussion of service-specific tactical and strategic implications of various developments in military technology. This study will, therefore, follow the latter model to enable us to comprehensively analysis the changes in strategy that have resulted from the evolution of military technology, especially since the first half of the 19th century.

Section-1

Military Technological Developments and Their Impact on Land Warfare

During the last quarter of the 18th century, and the first decade of the 19th century Napoleon revolutionised the operational strategy. However, this revolution was not powered by any major development in military technology[iii] but was brought about by changes in training, organisation and military doctrine that were enabled by a major social upheaval in the form of the French revolution, which allowed the raising of a mass army and Napoleon's military genius. As a result, the deficiencies in the available military technology that had hampered the development of military strategy became inconsequential. The only areas where the French enjoyed an advantage over others were more accurate military maps, better road network and better communication in the form of the 'Chappe' Telegraph system that could transmit messages to a distance of 400 miles in a day.[iv] There was hardly any difference in the weapons being used by the French soldiers and their adversaries. It may be of some interest to note that Napoleon, despite his innovative ways of war, was not amenable to new technologies, as is evident from the fact that he not only disbanded the Royal Balloons Corps but also rejected the first submarine developed by Robert Fulton.[v]

The year 1830 is considered a major landmark in the development of technology in general and military technology in particular, as many important inventions substantially altered the nature of warfare. Two of the most significant technological developments were essentially civilian in nature, but their combined effect widened the canvass of war to a great extent and raised it to an entirely different level. However, from the strategic point of view.

despite the advantages that accrued from both these technologies, these had serious shortcomings, namely ‘immobility’ and ‘inflexibility[vi] due to the fact that once the railway tracks and telegraph lines were laid on the ground, these could neither be moved nor reoriented. As a matter of fact, the layout and direction of railway lines betrayed the strategic orientation of a country even during peacetime. These were not the only problems to contend with. Since the railways in the early days consisted of single tracks with only a few crossing places, the coordination of movement of the trains moving in opposite directions was an extremely complex feat to perform and could only be accomplished with the help of an efficient telegraph system and strict railway timetables. This brought about additional inflexibility in strategic planning and required planning in peacetime to gain the advantage over the opponents in the mobilisation of forces and led to a temptation to initiate preliminary moves on the first indication of the onset of a crisis. That is why a strategic expert has remarked that the ‘First World War’ was imposed upon the European politicians by the railway time tables.[vii] It also brought about the need for detailed planning and coordination, which in turn required a specially trained cadre of military officers which led to the advent of the ‘General Staff’ system, the military-bureaucratic elite within the military ranks. While the railways and telegraph had great utility at the ‘Grand Strategy’ level, they were not so useful at the operational or tactical level. This is due to the fact that large armies, along with their logistics, could be carried by the railways quite easily up to the last railhead, but to move them from there onwards to the actual battlefield remained a serious problem until the production and large-scale induction of motor vehicles.[viii] Moreover, provision of large quantities of food, fodder, fuel and ammunition to large armies beyond the railhead onwards to the battlefield remained a major headache. Telegraph presented problems of its own, and though it provided good communication linkages between the field army headquarters and the civilian/military leadership back in the capital, the communication between the field army headquarters and the subordinate formations in the field was an insurmountable problem until the advent of the man-portable wireless sets. In many instances, the commanders were asked to stay close to the nearest telegraph post, which meant that they were detached from the battlefield, and the bond between the commanders and their troops was broken, with seriously negative impact on command and leadership. The historic Battle of Somme during the First World War exemplified this dilemma when officers up to battalion commanders' level were explicitly prohibited from accompanying their troops into the battle to remain in communication with the higher headquarters through a telegraph network. It was mainly the cumulative effect of these difficulties that led to a major stalemate during WW1.

While the strategy was transforming due to possibilities of widening the canvas of warfare and significantly increasing the range of military operations with the use of railways supplemented by telegraph, relatively smaller developments but with far reaching consequences for the future battlefields were taking place in weapons technology. These included the introduction of cylindro-conical bullets, rifled barrels, breech-loading mechanisms, metal cartridges, magazine-fed rifles, machine guns, smokeless gunpowder, TNT-filled explosive shells and mechanical time fuses. The cumulative effect of all these developments greatly enhanced the range, accuracy and rate of fire of small arms and field artillery guns. Additionally, the invention of the 'recoil mechanism' in 1897 incorporated by the French in their 75 mm field artillery gun greatly enhanced the effectiveness of artillery guns. One may wonder how all these significant developments followed one after the other during the 19th century. The fact is that all the ideas were already known to men for a long time but could not be implemented due to a lack of requisite materials and technology. However, in the 19th century, the products of the industrial revolution, such as steel, steam energy, requisite machine tools and processes to put these into use, made it possible to translate these into reality.[ix]

The overall effect of various developments in military-related technologies greatly enhanced the volume of fire that could be brought to bear on the battlefield. At the same time, the range to which this fire could be effective was also increased substantially, accompanied by enhanced accuracy with which the potential targets could be hit. The efforts to further increase the rate of fire have continued unabated, and in many cases, have already reached the optimum limits. With the advent of nuclear weapons towards the end of the first half of the 20th century, they have become the symbols of ultimate firepower and the currency of power in the modern age. In conventional weapons, the focus has shifted towards acquiring enhanced accuracy and reliability in tough battlefield environments.

The increased firepower changed the face of the battlefield in many ways. For instance, the increased density of firepower per square metre of the battlefield turned it into an extremely deadly place and as an author aptly commented, "warfare entered a new medium and increasingly took place in a storm of steel."[x] It also meant that the gross volume of firepower could now be increased by improvements in weapon designs rather than the old way of concentrating more soldiers on the battlefield. In simple words, ten soldiers firing 30 rounds per minute could generate the volume of fire thrice as twenty soldiers who could barely fire five rounds in a minute. Higher rates of fire increased accuracy, and longer ranges enhanced the killing power of each soldier. Moreover, machine guns which first appeared during the American Civil War, had achieved the capability to fire 650 bullets per minute by 1883, compared with just

3-4 rounds that could be fired by highly trained musketeers at the time.[xi]

The initial reactions to all these developments were neither logical nor well-considered. From the mid-19th century to the early 20th century, a fallacy persisted that the lethal effects of a considerable volume of fire likely to be faced by the soldiers on the future battlefield could be neutralised by greater emphasis on the offensive spirit to raise the morale of the soldiers. It was hoped that this, would enhance their will to fight, enabling them to overcome the deadly fire coming their way. The French pioneered this approach and succeeded to a limited extent at Solferino in 1859. However, when the Austrians tried to follow their example in 1866 during the Austro-Prussian war, they suffered catastrophic consequences in the face of the Germans' newly inducted 'Needle Gun'. In the final analysis where the commanders failed to find any feasible solution to the problem through their professional knowledge and collective intelligence, the instinctive reactions of the soldiers bearing the brunt of this hail of fire provided some antidotes to this problem.

They instinctively ducked behind whatever natural cover was available on the battlefield, thus transforming the landscape of the battle arena where for the first time in the history of warfare, the infantry ceased to fight, standing erect in organised formations. The new norm rushed from behind one cover to the next in small loose formations. This idea was, however, turned into institutionalised military practice decades later during the American civil war, in which both antagonists built and used extensive networks of field fortifications. A series of such fortifications were constructed to cover whole cities – a prime example being Richmond Virginia. The digging tools thenceforth became as important in a soldier's inventory as his weapon. The fortifications were reinforced by layers of barbed war, which was now mass-produced due to the large-scale manufacturing revolution. This complex was augmented by the lethal firepower of the newly introduced machine gun. This created the infamous trinity of the machine gun, spade and barbed war that became almost insurmountable for rival commanders, especially on the Western Front during the First World War.

The distant American Civil War failed to evoke the interest of European military strategists and as a result they missed some critical lessons which might have saved them a lot of sweat and blood during the First World War. The American Civil War witnessed for the first time the full impact of the products of the military-industrial revolution. However, the European observers were more impressed by the brilliance of the Prussian victories in the Austro-Prussian war of 1866 and then the Franco-Prussian war of 1870-71, which were achieved through the effective use of the Prussian railways' network to mobilise and deploy their forces. These campaigns were essentially wars of manoeuvre, and field fortifications were not employed at a large scale. However, in the intervening period between these campaigns and the onset of WW-I, the Russo-Turkish War of 1878, the Boer war of 1899-1901 and the Russo-Japanese War of 1904-5 provided enough evidence to suggest that the future of war would be in dugouts and trenches and that spade will play as significant a role in it as the rifle. It was also evident that the future wars will be long drawn out and savage in nature.[xii]

To ensure survival on the modern battlefield in the face of the increasingly voluminous and effective firepower of the new weapon systems, besides entrenchment, camouflage, which was already practised to enhance secrecy and effect surprise, also assumed added importance towards the end of the 19th century. The traditional battlefields that used to present a colourful exhibition of bright coloured uniforms and fanciful headwear instantly turned lacklustre and dreary. Despite initial resistance from the conservative soldiers, the new uniforms imposed by the necessity of survival were olive green, khaki, grey and sky-blue colours that helped camouflage and concealment. Rugged steel helmets replaced the plumed elegant hats to protect against bullets and shrapnel. Ironically, the steel helmets, which had previously been associated with industrial and mining labour transformed the war from an aristocratic to something like an industrial enterprise. This process of change has continued unabated to the present day, wherein camouflage printed uniforms are a common sight that not only provides concealment but also satisfies, to an extent, the soldiers' traditional preference for colourful and attractive outfits.[xiii]

The third method employed by soldiers to deal with the effect of growing lethality of firepower was dispersion which in effect meant a reduction in the number of soldiers per square metre of the battlefront. The density of troops on to ground during the times of the Greek phalanx used to be 1:1, which had slowly declined to 1:10 by the 18th century. The American Civil War witnessed the troops to ground ratio fall to 1: 25 (this was when the bulk of the weapons used were still the muzzleloaders with their slow rate of fire). The density was further reduced to 1:250 during the First World War, and a further reduction by many times more was experienced during WW2.[xiv] The dispersion has become even more important in the nuclear age. It is considered one of the most effective passive defensive measures against all weapons of mass destruction. The adoption of the leap-frogging tactics accompanied the reduced density of the attacking troops. As a result, despite the enhanced accuracy and lethality of modern weapons, the overall percentage of casualties suffered by the antagonists per battle day was reduced. It was natural for the senior commanders to resist the increasing trend toward dispersion since they feared that excessive dispersion would lead to the loss of effective control over troops on the battlefield. But once this came into effect by the beginning of the 20th century, it led to greater reliance on electric telegraphs and field telephones for strategic/operational and tactical command and control, respectively. This new phenomenon termed 'control by wire' gradually expanded until all formations from Corps to battalions were connected with wire.[xv]

The infantry found its offensive potential somewhat dented by the growing lethality of the firepower, but the cavalry was the worst sufferer. Cavalry, that hither-to-fore, had been the arm of decision now had its role downgraded to secondary tasks like reconnaissance, flank protection and surprise raids on isolated enemy positions. The cavalry still performed a very useful role by enhancing tactical mobility acting as mounted infantry between the railheads and the battlefield. Also, beyond the railheads, horse-drawn carts significantly transported logistic supplies from railheads to the edge of the battlefield. However, in the peripheral theatres of war such as Palestine, the Eastern Front between Germany and Russia, the Russian civil war and the Russo-Polish war, the cavalry still played a crucial role mainly due to the fact that in all these theatres, the availability of modern weapon systems was bare minimum. In the end, it was the introduction of the motor transport that, combined with the increased firepower, completely drove the horse-mounted cavalry off the battlefield.[xvi]

The enhanced rates of fire enabled by magazine-fed rifles, machine guns and quick-firing artillery were not without a cost due to the associated logistic problems. The under appreciation of these problems led to the stalemate during the first great war. The European armies drew from the experience of their most recent war between Prussia and France in 1870-71. During that war which had lasted for five months, each artillery gun of the Prussian army had expended 200 rounds on average. The rival troops entered the World War with 1000 rounds per gun ammunition stocks. However, due to the high intensity of battles, they consumed these stocks of munitions in merely six to eight weeks of fighting. Towards the end of the war in 1918, during the German and then the Allies' offensives, there were times when artillery batteries were firing as much as 450 rounds in a day. At the same time, the German army was consuming as much as 300 million rounds of small arms ammunition per month. It was already a gigantic task to make up for this huge consumption of ammunition and when added to it was the need for large numbers of spare parts and huge quantities of daily rations for the soldiers, it became an almost insurmountable challenge.

Despite laying hundreds of kilometres of railway tracks and employing large numbers of drought horses, the field armies' growing immobility and inability to operate farther away from the railheads could not be adequately addressed. It was difficult for an army corps to carry out operations at distances of more than 25 kilometres from the nearest the railhead due to the cumbersome task of moving the supplies from railhead to the edge of the battlefield. The introduction of motor vehicles eased the problem to some extent but presented logistic issues of their own due to the need for refuelling, spare parts and field repair and maintenance units. Bringing up the huge quantities of supplies from the railheads to the battlefield was just a part of the problem because once these supplies were dumped near the battlefield, moving them forward or backwards was equally onerous. This hampered the mobility of the armies to a great extent, and consequently, they found themselves bound to their entrenched positions until a complete stalemate was reached. When the soldiers made a breakthrough by employing innovative tactics, it could not be fully exploited because the logistics failed to keep pace with the advancing troops and forced the offensive to come to a halt. As a result of such operations, narrow wedges would be created in the enemy lines, which were then subjected to the enemy's counterattacks from three directions. The troops thus caught in these salient were subjected to artillery fire and toxic gases. The gases proved very effective against entrenched forces, and the same bunkers that protected artillery shells got filled with heavier-than-air poisonous gases. The gases also had a psychological impact far in excess of their actual potency. Moreover, the fighting efficiency of the soldiers forced to wear the protective equipment was degraded by almost 50%.[xvii]

It was commonly believed that the protracted trench warfare and the strategic and tactical deadlock proved defensive power over the offensive and that modern technology favoured the defence. However, it was not wholly true, and the same machine gun that had been so devastating in the hands of the defenders created a similar effect when carried by the assaulting soldiers. So, it is not the weapon per se which is more suited to a particular form of operations; it all depends on its employment in the battle that determines whether it is more effective in offensive or defensive mode in a given situation. Another example is the tank which from the outset has been considered primarily a weapon of offence. However, it has proven to be the defensive weapon par excellence when used in hull-down positions against attacking tanks, as was demonstrated by the Israelis at Golan Heights during the 1973 Arab-Israeli war. Though in many battles fought during the latter half of the 19th century, tactical mobility was brought to a standstill by the ever- increasing firepower, ultimately the operational and strategic mobility enabled by the railways and the use of exterior manoeuvres proved decisive. It was only during the first three years of WWI when the opposing forces had been ground to a halt, but by the wars' closing stages in 1918, both sides found innovative solutions to break the gridlock. These innovations comprised the introduction of both innovative weapons as well as tactics. The Germans, for instance, employed flame throwers to flush out the defenders from dugouts. The German assault troops also carried light machine guns and light mortars alongside innovative techniques such as infiltration and used predicted fire to achieve surprise. The allies, on their part, used a technological innovation by introducing the first tanks on the battlefield that allowed them to close up to the enemy trenches and overrun them. The early tanks were not sturdy enough to make deep thrusts, and their potential could also not be optimally utilised due to underdeveloped tank tactics. However, through all these changes, seeds were sown for the solutions to prevent the recurrence of the horrific stalemate of prolonged trench warfare.[xviii]

In the post-WWI period technical and tactical developments were not pursued with wartime zeal due to mental and physical fatigue caused by the unprecedented losses of the war. During the intervening period between the First and the Second World Wars, a fierce debate continued between the old school representing the views of the traditional arms, who viewed tanks and motor vehicles as an appendage to infantry and artillery to support their operations. While the other school, represented by the tank enthusiasts, advocated for the creation of armies consisting exclusively of tanks and mechanised forces while infantry and artillery if at all retained, should play a secondary role. However, since most senior officers at the end of the war belonged to traditional arms and the tank corps was still in its infancy, the former view appeared to prevail. As the events of the Second World War were to prove, neither side was accurate in its vision of future wars, and though the armoured and mechanised forces did win some spectacular victories in the early stages of WW2, ultimately, it was the infantry and artillery that had to slog it out with the enemy.

Despite of the poor economic conditions, the British, French, American, Russian and German armies developed and tested new types of armoured vehicles. The German case was very interesting, and since it had been prohibited to produce or experiment with armoured vehicles as per the terms of the Treaty of Versailles, it secretively conducted field trials of its tanks on Russian territory. The new tanks had improved firepower, better armour protection, faster speeds and greater radius of operations besides better mechanical reliability. By the beginning of the 1930s, all contemporary tank designs included the main gun mounted on the turret that could revolve around it. The shortcomings were limited firepower, sensitivity to terrain and lack of night fighting capabilities which seriously curtailed their effectiveness. It also meant that the grandiose designs of tank advocates of raising all tank armies remained pipe dreams. It had already been established during trials in Britain towards the end of the 1920s that the tanks would not be able to operate on the battlefield without teaming up with infantry and artillery. These trials also revealed that the speed and mobility of the tanks could only be optimally utilised. It also brought to light the fact that the mobility of the tanks could be fully exploited only if the infantry and artillery, as well as the logistic vehicles, had comparable mobility, which was an insurmountable goal to achieve due to the huge costs involved. Later on, support elements such as field engineers, signals and maintenance support units were also inducted, which on the one hand, made the armoured divisions self- sustaining and, on the other, made them unwieldy formations to move around.

At the commencement of the Second World War, only the German army had specially organised armoured divisions, and the Polish campaign in 1939 provided German Commanders with to test and practice handling these formations in real operations. The experience gained in this campaign proved very valuable in the subsequent campaigns in the Western theatre and the early Blitzkrieg operations on the Eastern front against the Soviets. A closer study of these campaigns suggests that these victories can neither be attributed to any technological advantage enjoyed by the Germans nor superior numbers. In many instances, the adversaries had greater numbers, and on occasion, even better machines. One area where the Germans had a clear edge was communications. While the allied tanks only had to receive sets, the Russian tanks had no wireless communication at all. The German tanks were equipped with two-way radio communications - this German superiority owed to ingenuity. In only one aspect of technology, albeit a very crucial one, the German tanks had the edge over the others. While most of the Allied tanks were equipped with only receiving sets and Russian tanks had no wireless sets at all, the German tanks were equipped with two-way radio sets, largely due to the resourcefulness and creativity of General Heinz Guderian and commander of the Signals Corps, General Fellgiebel (general commanding the signal troops). The superior communications greatly boosted the operational flexibility of German Panzers. The tanks did not win their victories due to firepower but because of their superior mobility and speed that caused paralysis in the enemy ranks.[xix]

The origin of the tanks can be traced to the need to subdue the deadly trinity of entrenchments, barbed wire and machine guns. However, due to its mobility, it was assigned the roles which had previously been performed by the horse cavalry, such as reconnaissance and flank protection etc. It was also found to be the most effective weapon system against enemy tanks. As always, it did not take long for the counters to start appearing in the form of anti-tank guns, the main weapon of the opposing tanks and later the anti-tank guided missiles. Confronted with the hostile fire, the reaction of the tanks was not very different from that of the infantrymen in the face of increasingly lethal fire on the battlefield during the second half of the 19th century. In the second half of the 19th century, the initial reaction was to rely on an overly offensive spirit to suppress the resistance but they faced increasing losses, and they were forced to modify their tactics. Armoured units and formations now advance under cover of artillery and air-supporting fire. Not unlike the infantry tanks, now employ leapfrogging tactics moving forward in short rushes between one cover to the other. One insurmountable problem has been the heavy logistic requirements of armoured divisions and the unaffordability of all tracked formations. The logistic support, therefore, depends on long convoys of wheeled vehicles which are road bound that slowing down the progress of tank formations. During the Second World War, the German Panzer divisions required 300 tons of supplies, while the American armoured formations needed 600 tons. However, the current armoured divisions consume between 1000 and 1500 tons of supplies. This, coupled with the incompatible mobility of the supply convoys retards the speed of tank formations.[xx]

From 1830-1945 changes in communications and transport technologies made a major impact on tactics and, in turn on strategy, such as the shift from interior to exterior lines in the latter half of the 19th century. These changes, however, were not fundamental in nature; the Blitzkrieg was not very different from the well-established German strategy of encirclement or the cauldron battles, the only difference being the modern means of mobility that had vastly increased the scale and reach of such battles. It may be of some interest here to note that during the German Blitzkrieg campaign in Poland, the Panzers achieved an average daily rate of advance of 11 miles, whereas, on the Western Front in the early stages of WWI, Von Kluck's army consisted of foot infantry and horse cavalry was expected to advance 15 miles per day. In the post-WW2 era, increasingly capable air power and the advent of nuclear weapons have profoundly affected the nature of warfare.[xxi]

The impact of technology advancements has not only transformed warfare on land alone but have brought about considerable changes in the nature of naval and air warfare. An overview of these changes has been provided in the succeeding paragraphs.

Section-2

Developments in Naval Warfare

Just as it happened in the case of land warfare, many technological developments came together in the 1830s to transform naval warfare as well. These included the improvement in the range and weight of naval cannons, which rendered wooden ships that had been the mainstay of navies for many centuries hazardous to sail out for battle. However, the invention of steam power made it possible to construct large naval vessels from the iron and later steel which helped address this problem. Initially, the new ships were still built with wood but were covered with thick sheets of iron to provide protection against cannon shells. These naval vessels were called ‘ironclads’ and were employed in battle for the first time during the American Civil War. These ships were equipped with not only cannons but rams as well. However, the ram went out of fashion with the increasing range of naval cannons. In contrast to steam railways, however, there was a constraint on the size of steam engines employed for naval propulsion. The restriction was due to the lack of availability of fuel when the ships were out at sea. The screw propeller introduced in the 1840s provided a suitable way of utilising steam power for naval propulsion. In Europe, the French took the lead in building the ironclads in 1859 but were quickly caught up by the British, who overtook the French due to their tremendous industrial potential. The era of ironclads was short-lived, and from the 1860s onwards, ships were already being built completely of iron and then of steel. The introduction of larger and more powerful ships also increased the size of naval guns, which now grew to 60 tons in weight with correspondingly heavier shells. However, this also imposed a limitation on the number of cannons that could be mounted on a ship and make their optimal utilisation. These were employed in steam-powered turrets rather than the customary deployment along the broadsides. To allow for all round firing ability of the guns, the rigging that had been a distinguishing feature of ship designs had to be done away with.[xxii]

The newer generations of battleships with faster speeds, heavier guns and better-armoured protection immediately rendered their predecessors obsolete. Though, at the strategic level, modern navies became less flexible regarding their operational handling despite their superior fighting capabilities. The shortcomings included the limited endurance of coal-fired ships, which rarely exceeded a few weeks – a relatively limited time in the vast arena of naval warfare. Access to either friendly or neutral or own overseas bases became essential for conducting long-range operations. These bases had to be stocked with coal, and repair and maintenance facilities. The need for overseas bases then led to the frantic race for colonisation amongst the major maritime powers, which picked up momentum after 1871.[xxiii]

In the case of the sailing ships, bigger ships had many advantages, including the ability to carry more ordnance and achieve greater speeds. However, with the introduction of steam power, smaller vessels became faster and more agile as compared to their bigger counterparts. Added to this was the torpedo, and the smaller ships adopting hit-and-run tactics became a serious threat to capital ships, including unwieldy battleships and even slower merchantmen. This development was more attractive for the continental powers like France, who embraced the new doctrine called 'Jeune - Ecole' – essentially a kind of maritime guerrilla warfare, which provided them with a means to attrite large navies like that of Britain. However, the success of this strategy was short lived, and in the end, the age-old theory of command of the sea prevailed. Speed became a major advantage in naval engagements, allowing the side with greater speed and mobility to manoeuvre itself into position from where it could bear maximum volume of fire on the opposing fleet. Another change was that the naval engagements were now fought at much greater distances, given the longer ranges of the naval cannons, and old implements like 'ram' went into disuse. The introduction of the turbine-powered 'Dreadnought' class of battleships by Britain immediately made the large fleets of cruisers meant to escort larger battleships useless since they could not keep pace anymore with the faster battleships. On the eve of WWI, the Royal Navy shifted from coal to oil as the fuel, which increased the range and operational flexibility on the one hand and increased the dependence on sources of oil supply on the other. These developments also impacted the psyche of naval commanders as they increasingly adopted a more circumspect approach and, instead of seeking battle, tried to avoid engagements to preserve their very costly ships.[xxiv]

The submarines had attracted the imagination of naval warriors as far back as the American War of Independence in the late 18th century. The idea, however, could not be translated into reality due to a lack of requisite technologies. It needed an appropriate means of propulsion, the ability to navigate underwater and a weapon that could propel itself when submerged. The propulsion problem was resolved when John Holland, an American inventor, came up with the idea of twin engines: an electrical engine for underwater propulsion and a diesel/petrol one for running over the surface to charge the batteries. Torpedo, a weapon propelled underwater by compressed air and with a range of up to 1 kilometre in the early days, ideally suited the submarine, and the two turned out to be a lethal combination. Developments in submarine technology had advanced to the extent that by 1914 the largest crafts weighed as much as 500 tons with a cruising range of up to 10,000 kilometres and carried 4-6 torpedo tubes. The biggest weakness of the submarine was its relatively slow speed. Though on the surface, it could move as fast as the merchant ships, it was far slower than the battleships, and under the surface, it could only travel at 3-4 knots. The implication was that once detected; the submarine would find it difficult to escape. Despite this shortcoming, the admirals had to reckon with the threat posed by the submarines and were forced to screen their fleets with destroyers and their submarines and thus impacted negatively on the operational flexibility of the battle fleets. However, an area in which the submarine excelled was attacking commercial shipping. During the First World War, no device could be developed that could help in the detection of an underwater submarine, and this hidden menace played havoc not only with the merchant vessels but large battleships as well. Once the British reverted to the convoy system with destroyers and submarines escorting commercial shipping, the losses were reduced but occupied many men of war in escort duties.[xxv]

In addition to the threat posed by the submarine from below the surface of the water, a new threat emerged from a different direction – the air. To begin with this threat was posed by land-based aircraft with obvious limitations of range. However, beginning in 1909, placing the aircraft on board the ships were being experimented with. These first-generation naval aircraft had floats underneath and would take off, land on the water surface, and then be lifted on the deck with the help of cranes. In response to this aerial threat, the ship decks were reinforced with steel plating, and besides normal cannons, anti-aircraft guns were also deployed on board. The British navy was first to convert one of its cruisers into an improvised aircraft carrier in 1921. The Washington treaties of 1922 that were meant to impose limitations on the weight and armaments of the battleships had the unintended effect of accelerating the development of the so-called ‘flat tops’, which were far lighter than the traditional battleships but could house up to 50 aircraft. The WW2 confirmed the dominance of the aircraft carrier, and only a few old-fashioned naval battles took place. In these new-style naval engagements, the opposing commanders fought each other without being able to see enemy ships except through the eyes of their pilots or as blips on their radar screens. It became too dangerous for any naval fleet to operate without air cover provided by their land-based air assets or carrier-based aircraft. The naval air power not only transformed naval warfare it also facilitated amphibious operations by helping to neutralise shore-based fire power of the enemy ahead of the arrival of the landing craft.[xxvi] The naval airpower also assisted submarine operations in two ways; first, it identified targets for own submarines and guided them in engaging these and second, equipped with decimetre radars these aircraft detected enemy submarines while cruising on the surface and then destroyed these with depth charges and air-launched torpedoes. In response, the submariners tried to protect themselves by mounting anti-aircraft guns and devices to alert them about radar transmissions.

'Acoustic sonar' had been developed by the end of WW-I to detect underwater submarines. It was further refined by the beginning of WW-II. It was, however, not without limitations of its own. The passive sonar is not very accurate and has a limited range, while the active sonar runs the risk of detection by the hostile submarine, which could itself launch an attack before being attacked. To this day, the detection of the submerged submarine poses one of the major challenges to scientists though technologies are under development that would render the sea 'transparent' as per claims. The advent of nuclear-powered submarines, which are not very quiet in operation due to their large size and the continuous operation of the nuclear power plant, provides advantages in terms of range, speed and endurance since they do not need to come to the surface for charging of batteries. The submarines, though, are not without serious disadvantages in the form of a cramped and stuffy operational environment for the submariners, but the biggest of them all is a lack of communication with the outside world, as only low and very low or extremely low frequencies can travel under water. Such communications require very tall shore-based antennas, which themselves remain vulnerable to hostile actions.[xxvii]

Section-3

Developments in the Domain of Air Warfare

Air Force is the youngest of the three armed-services. It is also technology-intensive and affords excellent speed and flexibility in operational employment. The aircraft came into being as a result of a long-held desire of men to be able to fly in the air mimicking the birds. The precursor of modern aviation was the hot air balloon experimented with by the Montgolfier brothers in 1783 in the French city of Lyon. The earliest balloon could hoist two men in the air. The subsequent development was the balloon filled with hydrogen gas which is lighter than air. This balloon was produced by another Frenchman by the name of J.A.C. Charles just a few months after the Montgolfier brothers. These inventions created a lot of interest in their potential military uses. During the Napoleonic era, pamphlets were printed depicting the complete units of the 'Grand Armee' being lifted by these balloons along with their horses and guns across the English Channel. The earlier balloons flew with the help of lighter-than-air gases, but since they could not be steered in the air, they would remain anchored to the ground and would be brought down with the help of attached strings. Due to this, their military utility was limited to providing long-distance observation behind enemy lines. Not too impressed by their limited utility Napoleon ordered the disbanding of the balloon corps. However, both protagonists used balloons during the American Civil War for deep observation. Again, during the siege of Paris in 1871, balloons were used by the besieged Parisians not only for mail delivery but also to transport the people.

The efforts to make the balloons steerable bore fruit when lightweight but strong materials were produced along with suitable means of propulsion resulting in the production of the first 'airships.' These were mostly manufactured and flown in Germany, Britain and

United States. The Germans extensively used the airships during WWI, mainly for long -distance reconnaissance and then for what came to be recognised as the precursor of the strategic bombardment. The development of the internal combustion engine enabled the flight of heavier-than-air machines. The American Wright Brothers are recognised as the ones who undertook the first successful powered flight though they were not the only ones. The others included Alberto Santos Dumont, a Brazilian, and an American Samuel Langley. The US Army financed Langley’s effort, but his failed flight, just nine days before the Wright brothers’ successful flight, led the US Congress to cut off all funding for the project. The obvious result of this cessation of funding was that leadership in the field of aviation went into the hands of the European powers.[xxviii]

Amongst the leading nations in the aerial domain, the Italians were the first to utilise the aircraft for aerial bombardment, long-range reconnaissance and direction of long-range artillery fire in the course of their military campaign against Libya in 1911-12. However, due to the limited resources the Italians had to concede the lead to Germany. At the beginning of WWI, the Germans possessed the best and the largest fleets of airships and aircraft. Initially, the roles assigned to the aircraft were mainly liaison and reconnaissance, but gradually a variety of missions were conceived for them. Since the aircraft in the early days were not armed, the pilots would take pot shots at their opponents with their pistols. As these aerial confrontations increased in frequency, the aircraft was equipped first with rifles and later with machine guns leading to the great aerial engagements of 1917-18 involving hundreds of aircraft at a time. A significant shortcoming was the lack of wireless communication, which hampered formation flying or mutual support. Wireless sets in those days were too heavy to be fitted on the aircraft. During the course of the Great War between 1914-18, many improvements introduced in the airframe structures, as well as engines, significantly improved the performance of aircraft in terms of speed, endurance, the maximum height they could attain, the ability to manoeuvre and reliability. By the time the war ended, the bi-planes and tri-planes being flown by various armies could go up to 3-4 kilometres in height in 12-15 minutes and achieve speeds up to 200 kilometres per hour. The Germans were undoubtedly technologically advanced, but others were not far behind. Rapid technological developments made older machines obsolete but irrespective of the technological advantages, it was ultimately the numbers that helped dominate the airspace. The aircraft had been employed for operational tasks such as the bombardment of each other's industrial hubs and population centres. However, once the parachute was developed in the final stages of the war, a new role of dropping troops behind enemy lines was also assigned to the aircraft adding a new dimension to warfare.[xxix]

During the initial stages of WWI, airpower played a limited role and the combined strength of aircraft of all belligerents at the time was not more than 500. However, there was a tremendous growth of the air arm to the extent that the Royal Air Force alone saw its manpower increase to 300000 men – an increase of 150 times from what it had at the beginning of the war. It also acquired as many as 50,000 aircraft of different types during the war. The thrill and fascination associated with aerial combat attracted well-educated young men mainly from the upper tiers of society, but despite their daring actions, which turned the pilots into icons, the role of air power remained secondary to the land and naval forces. This ancillary role of airpower was large because of the technological deficiencies of the aircraft available at the time. The early advocates of airpower like General Douhet from Italy and Billy Mitchell from the United States, however, ignored this aspect while arguing that that air force could win future wars all by itself through direct attacks aimed at destroying the war-making industries of the adversary and by breaking the will of its people. They erred on two counts; firstly, they completely underestimated the resilience of the people, and secondly, they overlooked the technological limitations of the aircraft, including limited payload capacity, slower speed, and lack of navigation instruments, especially during the night and in inclement weather, which were further compounded by the lack of accuracy in recognising and hitting the targets. During the period intervening in the two great wars, aviation technology saw significant improvements, and by 1939 the airships and bi-planes had gone out of fashion. Now the air forces had monoplanes made of aluminium instead of wood with the greatly enhanced power of the internal combustion engines. As a result, the aircraft could fly at more than 500 kilometres an hour and rise as high as 8000 metres or more. Additionally, two-way radio communications were installed in the aircraft, facilitating communication with their bases and ground forces and amongst themselves. This enabled close coordination between air and ground forces, as was demonstrated by the Germans during their successful Blitzkrieg operations during the early campaigns of WWII.[xxx]

The designs of the aircraft used in the Second World War depended on the roles envisioned for these by various forces. The Germans accorded greater importance to close air support of the ground operations, and their famous ‘Stuka’ dive bombers proved their effectiveness in this role, but the same aircraft failed to make an impact when switched to the strategic bombing of the British Isles due to limited payload capacity and short operational range. The allies who assigned higher priority to strategic bombing of the German mainland focused on building heavy four-engine bombers and producing lightweight single-engine interceptors and transport planes and gliders. The transport planes and gliders were employed for dropping paratroopers behind enemy lines. As expected, the technological advancements in aircraft led to the development of countermeasures. Interceptor aircraft was one, but anti-aircraft guns also came into the fray. Initially, these comprised improvised French 75 mm guns, but the specialised anti-aircraft guns soon appeared. Large balloons with steel ropes entangled low-flying aircraft were also hoisted around sensitive targets. The increase in intensity and accuracy of the ground fire made it difficult for the large slow-flying heavy bombers to hit their intended targets during daylight. They now faced a dilemma; if they resorted to low altitude bombing, they became vulnerable to ground fire, and if they tried high altitude bombing, their accuracy was severely affected. The safer alternative was to carry out night bombing, which caused difficulties in navigation, target recognition and accuracy of the bombing. Daytime missions also faced an additional hazard in the form of enemy interceptor aircraft until long-range fighters were produced in 1943 to escort their bombers. However, that method had its problems, requiring coordination of the movement of two different kinds of machines with diverse flight profiles. Moreover, there was the need for coordination with the ground controllers, meteorological stations and own air defences resulting in a closely knit system that significantly constrained the flexibility. On the ground itself, the air defences could not perform effectively without early warning of the incoming aircraft. Although this problem was addressed by the development of the RADAR providing information about the distance and the direction from which the incoming aircraft was approaching, it could only perform optimally in the form of a network covering all possible approaches and linked with its air defences as well as interceptor bases through communication networks. There was also the need for well-trained personnel to analyse the information and designate appropriate defence assets to deal with the threat. The role of the RADARS in neutralising the German aerial offensive during the Battle of Britain cannot be overemphasised. However, in the later part of WW-II, the pilots also adopted tactics such as using metal chaffs to clutter the radar screens.[xxxi]

The heavy bombers could carry large payloads but were unwieldy to manoeuvre and needed fighter escorts to defend them against enemy interceptors. This led to the development of fighter bombers which could carry out bombing missions and defend themselves. However, their load-carrying capacity was distinctly inferior to that of the heavy bombers. The results of the strategic bombing never met the expectations of the air enthusiasts, especially the sustained bombing of cities failed to break the morale of the people; it rather hardened it further. It was only in the war's closing stage in Europe, when targets were carefully chosen, focusing on major communication hubs and means of transportation, that it paid dividends in facilitating the Normandy landings and the subsequent offensive operations. The limitations of the airborne operations were exposed at great cost in terms of casualties as at Arnheim, and it was found out that such operations could only succeed if there were a quick link up with the ground forces. These troops obviously had limited staying power since they were equipped with light weapons and stood very little chance against the enemy supported by tanks and artillery. The dreams of air power theorists regarding the ability of the air forces to decide the fate of war by themselves only came to fruition with the advent of nuclear weapons.

The march of technological innovations continued after the Second World War, albeit at a much faster pace, especially in electronics, communications, intelligence, surveillance, target acquisition, precision-guided munitions, automation and moving on to autonomy. All these aspects, as well as the emerging technologies and future trends, will be dealt with in detail in the subsequent chapters. The Revolution in Military Affairs has profoundly affected the nature of war. All major powers invest heavily in futuristic technologies to gain an edge over their opponents. Where this race will lead to or when and whether it will end is only a matter of conjecture.

Section-4

Technology and Warfare in the Modern Era

The beginning of the modern era in the realm of militarily relevant technologies coincided with the drawing down of the Second World War in 1945. Besides other military innovations and developments, there was one development that overshadowed all that had happened in the past. In one stroke, nuclear explosives raised the stature of firepower to a new unprecedented level, wherein one aircraft carrying one nuclear bomb could decimate a whole city. Unlike in the past, all protective measures against this monstrous firepower proved to be worthless. Here was a weapon that could cancel out the effects of all other weapons and decide the fate of war all by itself. However, the destructive power of nuclear weapons was so magnitude long-lasting that these could not be considered like any other weapons of war. Due to the vast destructive potential of nuclear weapons, the outcome of any war where both sides would employ such weapons would be futile for both antagonists since the victor in such a war will be emerge no better than the vanquished. This had a profound effect on the way future wars would be fought, and henceforth, the purpose of military strategy would not be to fight, and win wars but to deter their occurrence.[xxxii] The ideas of air power theorists such as Italian General Douhet, Billy Mitchell of America and Air Marshall Trenchard of Britain which appeared to be far- fetched suddenly started to sound true since aircraft carrying nuclear payloads could decide the fate of any war all by themselves. This conclusion, at best, is debatable since it was not the air power per se but the explosive power of nuclear munitions that had made it possible. As it happened, it only took a few years before the role of aircraft as the primary nuclear delivery system was replaced by guided missiles with varying ranges and near certainty of arriving at the intended targets, while the aircraft was faced with increasing accuracy and lethality of the surface to air anti-aircraft missiles. However, it must be kept in mind that due to technological challenges and the limited availability of nuclear materials and financial resources, only a handful of countries possess these weapons. Most conflicts since the end of WW2 have been fought with conventional munitions, but the presence of nuclear weapons and the grim possibility of escalation of any conflict involving a nuclear weapon power to the nuclear level has cast a long shadow over these.

Amongst the changes brought about by the advent of nuclear weapons are the following:

•Nuclear weapons have supposedly prevented another global war similar in proportions to WW1 and WW2.

•Unlike the historical precedence, there has been no direct clash of arms between major powers armed with nuclear weapons, though they have been fighting on peripheries or through proxies.

•Europe, with its violent and turbulent history spread over centuries, has been largely peaceful, especially during the Cold War and with some aberrations such as the conflict in the Balkans and the conflict between Russia and Ukraine.

•No war has been fought since 1945 involving the use of nuclear weapons whether one or both of the belligerents had access to nuclear weapons.[xxxiii]

The technology has, in the meantime, also made substantial progress in the realm of non-nuclear weapons, especially the introduction of guided missiles, precision-guided munitions, fire and forget type munitions, the revolution in information technology wherein a soldier fighting on the battlefield has direct access to real-time information received through satellites and has the ability to process this wealth of information to be utilised for his mission with the help of his man packed computer. The details of some of these systems would be explained in some detail in the succeeding paragraphs. It may, however, be pertinent here to carry out a brief survey of the evolution of nuclear strategy in consonance with the advancements in nuclear explosives technology and, more significantly, the developments in nuclear delivery systems.

Evolution of Nuclear Strategy

It may be to clarify here that in the interest of brevity and remaining within the scope of this chapter, it would not be possible to carry out a comparative analysis of nuclear strategies of all major nuclear powers, and since the bulk of published literature pertains to US nuclear strategy, it will remain the focus of this overview. When the nuclear age dawned after the nuclear bombing of the Japanese cities of Hiroshima and Nagasaki in August 1945, the US had a virtual monopoly over this technology. It was evident that this monopoly would not last for very long; however, the Soviet Union joined the exclusive club sooner than expected in 1949,[xxxiv] though the US continued to retain superiority in numbers of nuclear weapons and the sophistication of weapons' designs. By the early 1960s, the Soviet capability had advanced to the extent that a situation of parity was reached between the two superpowers.[xxxv] They did not stop there, and the unbridled nuclear arms race led to both sides possessing over 30,000 weapons each enough to destroy the planet earth many times over until the collapse of the Soviet Union and the end of the Cold War. However, we are witnessing the beginning of a new Cold War and a renewed arms race between the US on the one hand and Russia and China on the other.

The technological developments and changes in the international security landscape provided the backdrop for the nuclear strategy to evolve from one strategic concept to the other. After causing widespread carnage at Hiroshima and Nagasaki, the Americans were a bit reluctant even to consider nuclear weapons in their war plans. However, a series of development in rapid succession in 1949 and 1950 changed the whole outlook. North Atlantic Treaty Organisation (NATO) was established in April 1949, in the backdrop of the Berlin crisis. Lord Ismay, the first Secretary General of NATO, had famously said that the purpose of NATO was to "keep the Russians out, the Americans in and the Germans down."[xxxvi] As the later events were to show, the first two objectives on NATO were fulfilled, but the Germans could not be kept down for long. Due to the inability of the NATO members to raise a sufficient number of troops, there was no choice left but to allow the German rearmament in 1954. From then onwards, Germans and the Americans, provided the bulk of the NATO fighting forces in Europe.

The Allies had hardly recovered from a prolonged crisis emerging out of the Berlin blockade by the Soviets and the ensuing airlift of essential supplies to the Western zone of Berlin lasting from June 1948 to May 1949,[xxxvii] when on the 29th of August, the Soviets successfully tested their first nuclear device breaking the American nuclear monopoly. Then, in October 1949, the Communist revolution led by Mao Tze Tung triumphed in China,[xxxviii] giving a significant boost to the Communist movement and was considered to be a major setback to the free world. In 1950, war broke out on the Korean peninsula,[xxxix] while NATO was still in its infancy. Though in a peripheral theatre, this war was viewed by the Americans as a deliberate distraction caused by the Soviets. The NATO forces remained vastly inferior to the Soviets, and the force goals of fielding 92 divisions agreed during the Lisbon summit in 1952[xl] could not be met because of the economies of Western European countries devastated by the war. In this backdrop, President Eisenhower ordered a review of the US policy. The outcome was what came to be known as the 'New Look Policy.'[xli] The realisation that the American economy would not be able to sustain any major expansion of the conventional forces led to the decision to place more reliance on nuclear weapons to compensate for the conventional inferiority and to deter any major Soviet invasion of Western Europe.

Despite this clear policy decision, no nuclear use doctrine was formulated, and the choice of targets for available nuclear weapons was left at the discretion of the Strategic Air Command (SAC), which continued to conceive of the use of nuclear weapons on the pattern of strategic bombing. It was only in 1954 that John Foster Dulles, Secretary of State in the Eisenhower administration, outlined his famous 'Massive Retaliation Doctrine.'[xlii] In short, this doctrine stipulated that any Soviet attack would invoke a massive response with nuclear weapons directed at the Soviet mainland. Given their comparative weakness, the conventional forces were assigned no significant fighting role and were reduced to acting only as a 'trip-wire' warning of the onset of a Soviet invasion, and then the nuclear weapons would take over. It wasn't a very sophisticated doctrine and was predicated on US superiority in the size of the nuclear arsenal and in the number of long-range bombers, which were the only nuclear delivery platforms at the time. Moreover, the US had access to numerous overseas bases, especially in Europe, from where these bombers could easily reach the Soviet heartland. Thinking of a more refined doctrine was hampered by the early generation city buster-type weapons and lack of choices in delivery. The inflexibility and crudity of the doctrine lay in the fact that whereas it might have been rational to employ it in the event of a major Soviet invasion of Western Europe, it would have been imprudent in case of a minor infringement, especially in a peripheral theatre of conflict. Towards the late 1950s and early 1960s, when long-range ballistic missiles became the primary carriers of nuclear weapons, thereby enhancing the employment options.

When President Kennedy, who had been critical of this doctrine, took office in 1961, he ordered a review of the nuclear strategy under his Secretary of Defence Robert McNamara, who came up with his new

'Flexible Response' doctrine in 1962.[xliii] The new doctrine was intended to meet the Soviet aggression at a commensurate level following a graduated response starting with conventional defence, failing which it would be raised a notch to the use of battlefield nuclear weapons, then to the use of theatre nuclear weapons and ultimately to the strategic nuclear exchange between the two super-powers aimed at their respective homelands. There would be deliberate pauses between different levels of violence to allow space for negotiations and crisis management. Priority would be given to 'Damage limitation' and 'Counter Force targeting.'

This doctrine had its own limitations. Firstly, it could only work if the Soviets agreed to the American rules of the game, which they were not bound to follow. Second, it required substantial building up of the conventional forces, which did not materialize until the mid-1970s due to American commitment to the Vietnam War. Third, it required it required a large variety of nuclear weapons in large numbers. In view of these glaring weaknesses, McNamara had, by 1964-65, already started moving towards the 'Strategy of Assured Destruction,' which envisaged causing unacceptable retaliatory damage to the extent of 1/3 to 1/5 of the Soviet population and 3/4 to 1/2 of its industry. It was soon realized that by that time the Soviets had developed their nuclear capability to the level they were now capable of causing damage of similar proportions to the US. Donald Brennan then aptly coined the term Mutual Assured Destruction (MAD).[xliv] However, NATO adopted Flexible Response as its official doctrine in 1967 and stuck to it until the end of the Cold War since it was seen as a guarantee to link the American nuclear deterrence to the European defence by keeping some US nuclear assets on the ground in Europe to maintain this linkage.

Richard Nixon strongly criticised this doctrine in a message to Congress in 1970, claiming that the doctrine does not leave much room for the President other than choosing between 'suicide' or 'surrender' implying that it would be difficult for any President to order the "mass destruction of enemy civilians, in the face of certainty that it would be followed by the mass slaughter of Americans." A high-level team of experts led by National Security Advisor Henry Kissinger was established in 1972. The group came up with what came to be known as the 'Strategy of Limited Nuclear Options.' It was also called the 'Schlesinger Doctrine'. The doctrine emphasised 'escalation control' through a series of limited/selective strikes with pauses in between to allow for a negotiated ceasefire. This was a war-fighting strategy, made possible by the availability of more accurate missiles and MIRVED (Multiple Independently Targetable Re-entry Vehicles) Warheads. For instance, the US minuteman-III missile had an accuracy of two hundred metres at Intercontinental ranges.[xlv]

When the Carter administration took charge, they showed an inclination to revert to 'Assured Destruction' to begin with, but then embraced the Schlesinger Doctrine. However, a review initiated by President Carter in 1977 produced a new doctrine announced by the Secretary of Defence Brown in 1979. The new doctrine came to be known as the 'Countervailing Strategy'. This strategy was designed to convince the Soviets that they will be denied victory if they resorted to the use of nuclear weapons irrespective of the scale of attack or the stage of conflict by imposing unacceptable costs. The main features of this doctrine were; counter-force targeting, targeting the Soviet leadership and their ability to fight a long-drawn-out nuclear war. Again, these choices could be made due to the availability of highly accurate delivery systems and requisite warheads.[xlvi]

When Ronald Reagan took over the Presidency in early 1981, he had a more aggressive mind set towards the Soviet Union, evident by his characterisation of that country as an 'evil empire.' This outlook was reflected in his nuclear doctrine as well. He discarded the Countervailing Strategy as too timid and introduced a new doctrine termed the 'Prevailing Strategy.' The doctrine was aimed at ensuring American victory in all circumstances rather than merely denying victory to the Soviets.[xlvii] Reagan then made his well-known 'Star Wars' speech in March 1983, in which he pronounced his ambitious 'Strategic Defence Initiative' (SDI), which was meant to prevent any Soviet Nuclear Missiles from arriving at the American mainland.[xlviii] By that time, however, the Soviet Union was badly stuck in the Afghan war and showing signs of fatigue and decay. With no capacity to respond in kind, the Soviets could only protest against this doctrine for its deleterious effects on the strategic balance. The Soviets could not counter this challenge and the end of the Cold War meant that both the interest and the funding for this ambitious programme waned in America.

The Conventional Battlefield

In the post WW-II era, developments in conventional warfare and weapon systems have taken place in the backdrop of nuclear weapons. Until the mid-1960s, in the context of the East/West confrontation, conventional forces were only expected to perform the role of a tripwire to warn of an enemy attack and to trigger off the unleashing of the nuclear forces. However, with the adoption of the Strategy of 'Flexible Response' by NATO, which envisaged meeting the conventional threat at the conventional level before escalating to the use of nuclear weapons in case the enemy makes a major breakthrough, the role of conventional forces was considerably enhanced. However, the desired level of conventional forces to meet the demands of the new strategy, could not be achieved due to American involvement in the Vietnam War. By the mid-1970s, the situation changed due to two developments. Firstly, the US disengaged from Vietnam, and secondly, the Emerging Technologies, especially the Precision Guided Munitions (PGMs), enhanced the confidence in the ability of conventional forces to successfully retard any Warsaw

Pact attack and to provide sufficient time for NATO leaders to react and to resolve the crisis through negotiations. This trend was also encouraged by the performance of the PGMs in the 1973 Arab -Israeli War, where these platforms were used on a large scale for the first time. Consequently, doctrines such as the 'Air-land Battle' and 'Follow-on-Forces Attack' (FOFA) were developed.

The composition and capabilities of the Conventional Forces have also experienced profound changes during the past five decades or so. Some of the more significant ones are briefly described in the following paragraphs as under:

*There has been an ever-greater degree of mechanisation and technological sophistication, making these forces prohibitively costly to raise and maintain. Due to the high costs involved, armies in the developed world are still mostly organised around foot infantry, and for long-distance mobility, wheeled vehicles are used as troop carriers.[xlix]

*Superior technology of weapons and equipment has emerged as a major though not the sole war-winning factor. This has been demonstrated during the Arab-Israeli Wars, the Gulf War in 1991, the Kosovo war, and more recently in the early stages of wars in Afghanistan and Iraq. The Western supplied technologically advanced weapon systems being constantly supplied to Ukrainians in their ongoing war against Russia have played a vital role in prolonging the Ukrainian resistance.

*Given the high cost of major items of weapons and equipment, it is no more affordable to purchase these in large quantities, especially in the case of modern tanks, fighter aircraft, naval vessels and guided missiles, with costs ranging from a few million dollars to hundreds of millions of dollars per unit of equipment.[l]

*Today's main battle tanks are many times faster than those employed during WW-2; however, their fuel consumption is at least twice as much, adding to the already considerable logistic problems of armoured formations.[li]

*To operate the technologically sophisticated weapon systems, there is greater demand for better educated and highly trained soldiers and officers. The implication is that, unlike the past conflicts, it would be extremely challenging to raise large armies during a major conflict. This would also mean that the fighting effectiveness of the reservists would be significantly reduced due to rapid advances in military technologies.

*The expensive pieces of equipment constrain the maintenance of large war reserves, and the technological complexity and costs would make it even more difficult to quickly make up the deficiencies after the onset of a conflict due to higher attrition rates.

*Most militaries have been forced to prolong the life of major equipment items to avoid decreasing inventories due to the inability to induct costly equipment. The life span of modern aircraft is 20-25 years on average, but many countries are still operating aircraft of the 1970s and 1980s, vintage through mid-life upgrades, overhauling and refurbishments. For instance, Pakistan Air Force is still operating Mirage 3 and 5 aircraft acquired in the 1970s and the F-16 aircraft initially purchased in the early 1980s are still the frontline fighters. The Indian air force operates even older Mig-21s, 1980s vintage Mirage-2000s and Jaguar aircraft. So is the case with many other forces. Similarly, 50 years or older tanks are still in use naval warships are in service for 3-4 decades or more and aircraft carriers are frequently retained in service beyond 50 years.[lii] This has been made possible by a phenomenon called ‘Gold Plating’ which essentially means installation of modern weapons and sensors on the old platforms. Due to the introduction of long-range Radars and Beyond Visual Range (BVR) air-to-air missiles, a 30-years-old aircraft is more likely to shoot down its much younger opponent with less capable Radar, avionics and a shorter-range missile.

*The high 'kill probability' of precision guided missiles, which in most cases is 80-90 %, means that if their performance in battle conditions is somewhere closer to their designed capacity, most of the opposing platforms will be destroyed in a short span of time. This leads us to the conclusion that future wars would be highly destructive, short and intense.[liii] However, large militaries like India and Pakistan, with only a sprinkling of PGMs and other sophisticated systems, would largely be fighting more traditional types of wars. Interestingly, suppose the advanced weapon systems failed to perform to capacity in demanding battlefield conditions. In that case, it might lead to a stalemate with both sides left with useless platforms with no projectiles to fire due to exhaustion of small inventories maintained due to high costs and limited shelf life.

*The large-scale use of Night Vision Devices (NVDs) such as goggles, night sights and binoculars will turn any future battlefield into 24 hours affair, giving no respite to the soldiers thereby subjecting them to additional stresses and strains.[liv]

Developments in Modern Military Technologies

Modern military technologies displayed their destructive capabilities and effectiveness in actual operations on a large scale during the 1991 Operation Desert Storm – the war between the US and allies on the one hand and Saddam Hussain's Iraq on the other. However, the lessons from this war should be derived very carefully since this conflict was a lopsided affair. While one side was equipped with some of the most advanced weapons and equipment, the other side i.e., Iraq, was fighting with obsolescent and outdated weapons. The reputation and potential of the Iraqi forces were blown out of proportion as consequential to the eight years long war between Iran and Iraq. Many analyses of the war appeared in the immediate aftermath of the conflict, thereby denying the opportunity for a coolheaded and rational analysis and the proximity of these analyses meant a narrow perspective. That is why eminent strategic analysts like Professor Elliot Cohen were highly sceptical of some of the conclusions emanating from these post-war studies. Such scepticism was justified by later revelations about the poor battle performance of weapon systems such as the 'Patriot' missile defence systems, which were prematurely glorified. Modern military technologies can be classified under four main categories as follows:

1)Technologies related to Surveillance and Target Acquisition: These technologies provide surveillance and target acquisition capabilities in real-time and at long ranges.

a.**Sensors and Guidance Systems for Smart and Ultra-Smart Missiles:** These systems enable the detection, identification and engagement of tanks and other armoured vehicles, Aircraft and Warships and hardened targets with relatively small dimensions such as Command and Control Centres with a high degree of precision. These types of missiles are essentially 'Fire and Forget' type and, once fired, do not require instructions from the launch platforms.

b.**Powerful Conventional Warheads.** These modern warheads produce a high yield to weight ratio and are enormously lethal and destructive.

c.**Computerised C3 I Systems**. These computerised systems are capable of rapid processing of large volumes of information being received from various ground and space-based sensors and therefore help the commanders in decision making as well as transmission and receipt of orders.[lv]

It may be of interest to have a brief overview of some of the systems illustrative of the characteristics and capabilities of the modern weapon systems.

Reconnaissance Systems:

In the bygone days, a military commander was highly rated if he could imagine what was on the other side of the hill. In modern times the advanced long-range surveillance and target acquisition technologies have equipped military commanders with unparalleled reconnaissance capabilities. The commanders are no longer required to imagine enemy forces' strength and movement anymore since the available sensors enable them to look deep into the enemy territory. These sensors are installed on satellites, manned aircraft and increasingly on remotely piloted vehicles (RPVs) and consist of devices such as photographic and television cameras, infra-red, radars, x-ray and Gamma-ray sensors to electronic signals monitoring equipment. These systems can be employed singly or as part of an integrated system. A typical example of an integrated surveillance system is the American Joint Surveillance and Target Attack Radar System or the 'JSTARS.' It is based on an airborne radar system which helps in the acquisition and tracking of the targets and guides the weapons onto these. The JSTAR flew about 50 kilometres inside its territory and equipped with a powerful-side looking radar that could locate enemy tanks and other moving targets at a distance of around 150 kilometres. The information gathered by the JSTARS is transmitted to a computerised control centre. After analysing launches suitable guided missiles which, are then guided onto the target by the radar. The future trend would be to mount long-range reconnaissance devices on the RPVs instead of the piloted aircraft, which are not only very costly but very susceptible to interception by hostile air defence systems. Moreover, the RPVs, due to their low cost, can be employed in large numbers.

Guidance Systems:

One of the salient features of modern weapons is their unprecedented accuracy and precision owing to the mid-course and, more importantly terminal guidance systems incorporated into these. As a result, the accuracy is unaffected by ranges. Various devices such as radars, lasers and on-board computers are employed for terminal guidance. Such devices scan the area around the targets and compare it with the map information stored in the on-board computers. They then transmit signals to carry out necessary course corrections and then guide the weapon onto its designated target. One such system used in cruise missiles is called Digital Scene Matching Area Correlation (DSMAC).[lvi] Another commonly used system in cruise missiles is called Terrain Contour Matching (TERCOM),[lvii] which is basically a digitised map of the path to be followed by the missile up to its target, which enables the on-board sensors to continuously compare this information with the terrain below and initiate course corrections if needed. Most of the modern missiles are highly accurate and 'fire and forget' type weapons requiring no further instructions or guidance by the operator once launched. They also have the capability to pick suitable targets and then strike at their most vulnerable part, such as the tank turret.

New Conventional Warheads:

A new conventional weapon with destructive potential nearing weapons of mass destruction is 'Fuel Air Explosive'[lviii] which was employed by the coalition forces during the war with Iraq in 1991. Once launched, the weapon creates an aerosol cloud of Propylene Oxide vapours. After mixing with the air, the chemical becomes highly explosive and inflammable. Once the aerosol cloud has expanded to its optimal size, it is ignited, resulting in an explosion that is 5-10 bigger than the one that could be achieved by using a similar quantity of conventional explosives. If several such clouds are produced in synchronisation with each other, the combined effect on their ignition is comparable to a low-yield nuclear detonation. Soldiers who find themselves in the shadow of the explosive cloud die as a result of suffocation and damage to their lungs.

Cluster bombs and fragmentation munitions are now familiar varieties of modern conventional munitions. Rockets carrying these sub-munitions on explosion cover a large area. Some of these bomblets are made of plastic, and their fragments are difficult to trace in the body of an injured soldier as x-rays cannot detect them. The Vaught Multiple Launch Rocket System (MLRS) can fire rockets filled with anti-personnel bomblets. Each rocket measuring approximately 4 metres in length and 23 centimetres in diameter, carries 644 bomblets. A Salvo of 12 rockets can be fired in less than a minute, which can be repeated within 10 minutes. Its range is in excess of 30 kilometres. A single salvo of MLRS rockets contains around 8,000 bomblets which can cover an area of approximately 60 Acres with anti-personnel fragments and can cause as many casualties as a low yield nuclear warhead.[lix] These rockets can also carry shaped-charge anti-tank bomblets. More advanced versions of warheads being developed for MLRS will carry cluster munitions with as many as 28 parachute-controlled anti-tank mines, while another variety will contain 6 terminally guided anti-tank shaped charge projectiles. The ranges of the latest versions of MLRS are in excess of 100 kilometres, and many countries are now producing these indigenously.[lx]

Computerised C3 I Systems:

The sequence of action in a modern battle follows the following steps. In the first phase, the enemy forces are located, identified and tracked. The purpose is to evaluate the adversary’s intended objective and estimate the strength of the forces he is likely to commit. Next, an overall assessment of the emerging threat is carried out, which helps in the decision-making to deal with the threat. In the third stage, requisite weapons are chosen and fired at the enemy forces. Finally, in the fourth phase, damage assessment is undertaken using reconnaissance devices to confirm whether or not the threat has been effectively eliminated. Activities in the first and fourth phases are military intelligence functions. while those in the second and third phases are in the domain of command, control, and communication or C3I.

Intelligence agencies use a large variety of sensors for the purposes of reconnaissance, while command and control organisations employ different types of navigational devices to find out the location of friendly forces and to determine the position of hostile targets. However, the volume of information collected by all these sensors is so huge that its timely analysis and conversion into the form suitable to assist the commanders in decision-making is only possible with the help of modern computers. Which are now increasingly incorporating Artificial Intelligence (AI) for rapid processing of data as well as offering different response options for the decision-makers. Military command and control systems are, therefore, becoming increasingly dependent on powerful and sophisticated computers.[lxi]

The most significant developments have taken place in the field of communication technologies. However, these systems are not free of hazards. For instance, an enemy attack is likely preceded by a covert attack aimed at sabotaging communication and computer networks. If successful, such an attack will paralyse the whole command and control system which is getting increasingly dependent on these devices. Another problem is the difficulty to absorb and utilise the enormous amounts of information flowing through a variety of sensors. In the words of Professor Eliot Cohen:

"Small wonder that a group of senior Marine Corps Officers, led by the Assistant Commandant of the corps, visited the New York Stock Exchange recently to learn how brokers absorb, process, and transmit the vast quantities of perishable information that are the life blood of the financial markets." 62

Conclusion

An attempt has been made to provide a brief overview of the developments in nuclear and conventional technologies since the end of WW-II, which have virtually changed the face of the modern battlefield. It is by no means an exhaustive and all-embracing analysis. However, most of the developments in key areas of interest have been surveyed in as simple terms as possible with a view to develop a linkage between the advancements in military technology and changes in the conduct of war. The accent has been on highlighting the trends rather than discussing the technical characteristics of individual weapon systems. One area which has not been treated in any detail though no less significant than other technological developments has been related to the 'Ballistic' and 'Cruise' Missiles. But those technologies have such a vast array of applications in both nuclear and conventional fields that they merit a separate study of their own.

End Notes

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[iii] Buzan, 18; Creveld, 167.
[iv] Creveld, 155.
[v] Creveld, 167.
[vi] Creveld, 168.
[vii] Ken Booth, in John Baylis, Ken Booth et al eds., Contemporary Strategy; London, Croom Helm, 1987, p 37.
[viii] Hew Strachan, European Armies and the Conduct of War; London, Unwin Hyman, 1983, p 123. Also see Buzan, 23.
[ix] Hew Strachan, 119; Creveld, 170-71.
[x] Creveld, 171.
[xi] Buzan, 20, Strachan, 113-14.
[xii] Colin McInnes eds., Warfare in the Twentieth Century; London, Unwin Hyman, 1988, p 51-2; Creveld, 171; Strachan, 113-14,116.

[xiii] Creveld, 171-2.
[xiv] Creveld, 173.
[xv] Creveld, 174.
[xvi] Strachan, 121; Creveld, 174-5.
[xvii] Creveld, 175-6; Strachan, 123; McInnes, 60.
[xviii] Creveld, 177; McInnes, 64.
[xix] McInnes, 64,68; Creveld, 178-80.
[xx] Creveld, 181.
[xxi] McInnes, 68.
[xxii] Buzan, 18,22; Creveld, 199-202.
[xxiii] Creveld, 203-4.
[xxiv] Creveld, 204-7.
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[xxvii] Creveld, 214-16.
[xxviii] Creveld, 183-5.
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[xxxiii] Joseph S. Nye Jr., 'Understanding International Conflicts', New York, Longman, 1997, 121-4.
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