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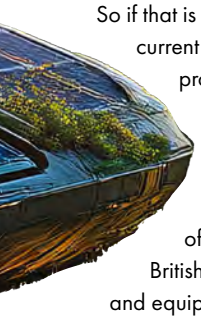
FOREWORD: **MAJOR GENERAL (RETD) DR ANDREW SHARPE**

‘AN ENLIGHTENED APPROACH TO STEALING A CAPABILITY MARCH’

EXPERIENCE tells us that there have frequently, over the centuries, been moments in the evolution of warfare, when either context, events or technology (or perhaps, more often, a combination of the three) bring about significant changes in the character of warfare. Perhaps more accurately than ‘moments’, it would be better to say ‘stages’, for these occurrences tend not to be sudden or momentary, but rather to develop over a period of time. It is those who have recognised the true nature of the changing circumstances in which they find themselves, and the opportunities that such transitions offer, that find the sought-after so-called force multipliers that offer them significant advantage in the battlespace. Often, importantly, these circumstances do not develop as expected or intended, but rather find their true potential as a result of having been moulded for advantage by those who, either by inspiration or by measured consideration, see through the uncertainty of novel circumstance to recognise the path to advantage.

We explore, in this *British Army Review Special*, a number of examples of such occasions. The tank, invented by the British as a mobile pill box to achieve a break-through in trench warfare (to allow others, like infantry storm-groups and cavalrymen, to break out and defeat the enemy in depth

though manoeuvre), only came of age when a German army (that had no tanks) recognised the capability's true potential in exploiting the break-through, rather than just achieving it. A couple of centuries before tanks appeared, the evolution of the infantry firearm into the musket changed European warfare, where soldiers had until that point come in one of three types: nobles who had the time and resource to train and equip themselves for skilled combat; artisan experts (like English longbowmen, Genoese crossbowmen, or professional bands of Landsknechts); or unskilled peasant levies. And when those newly professionalised European armies met the circumstances of the French Revolutionary Wars a new concept of operational art emerged, giving extraordinary advantage to those who first understood its true implications. What did nuclear weapons do to international strategy? And how did nuclear propulsion change the nuclear weapon dynamic? What have uncrewed aerial systems, and drones of all shapes and sizes, done to the modern tactical battlespace? We will explore all of these questions, and more, in the following pages in order to set the scene for a discussion about what is, perhaps, an emerging moment of opportunity which, if recognised, seized and exploited, might just help to deliver the two-or-three-times multiplication of combat effectiveness that the Chief of the General Staff is currently asking of his Army.



So if that is the background, what is the current context? Climate change has produced an environment in which fossil-fuel-powered machinery may have passed its moment as humankind's preferred mode of transport. The 'peace dividend' of the end of the Cold War saw the British Army shed numbers of personnel and equipment, and that lack of equipment has been compounded in recent years by the donation of many capabilities, such as every single piece of the British Army's tracked 155 artillery, to Ukraine; and thus, a hollowed-out British Army needs to re-equip itself for the twenty-first century. President Trump's re-ascent to power in the US, and the wake-up call of Ukraine, have generated an increasing re-acceptance by the political classes across Europe that the first duty of a government is to take security and defence issues more seriously than has been the case since the end of the Cold War. The British Government's announcements on Defence spending in February this year (2025) are a symptom of this.

All of these circumstances, as they combine together, suggest that there has not been an imperative so strong, nor a moment so apposite, for imaginative and urgent reform and rebuilding of British Army capability. Among the various work-strands of developmental thinking in the Army Headquarters, the British Army is currently exploring 'green' options for what it is calling 'operational energy'. It may be that this combination of context (a climate imperative for novel, planet-friendly, technology everywhere (not just in Defence)); a strategic context imperative for strong Defence; and a practical imperative to re-arm a too-hollow Army, if captured and recognised for what it could be, could be exploited for considerable advantage. It may be that the demands of climate-change-positive constraints could actually become opportunities for asymmetric advantage.

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This short *British Army Review Special* will therefore unpack the context of the past; touch upon the current context; and offer avenues of inquiry into technological options for equipping an army within the coming context. It will then invite you to consider how, with a bit of imagination, energy and commitment (and a rather more enlightened approach to force development and capability acquisition), the Army might be able to steal a capability march on others by recognising and exploiting one of those 'sea-change-moments' before others do. **– Major General (Retd) Dr Andrew Sharpe, Director of the Centre for Historical Analysis and Conflict Research**

‘BIG BANG’ MOMENT: THE GENESIS OF MILITARY INNOVATION

AUTHOR

Professor Matthias Strohn is Head of Historical Analysis at the CHACR.

IN 1359, a German Franciscan monk called Berthold Schwarz is said to have created a mixture which, when put on a stove, exploded. Even though this story is now seen as fictitious, this monk gave his name to a mixture which revolutionised the conduct of war: gunpowder or black powder (schwarz being German for black). We now know that gunpowder was invented in China, possibly as early as the ninth century, but it remained unknown in the West until the 13th century. Records show that gunpowder was made in the Tower of London in 1346 and that a powder house existed at the site in 1461.[1]

To begin with, the use of gunpowder was predominately restricted to the artillery, however, siege weapons – large guns (which were difficult to produce and transport, and used to breach the walls of castles) – followed. A specialist trade of gun-making developed, with the resulting wares often offered to the highest bidder. Perhaps the most famous example of this is the Basili, also known as the Ottoman Cannon. Built by Orban, a cannon engineer from Transylvania, it could fire a 540kg cannonball over a distance of 1.6 kilometres. Orban had offered the gun to Constantine XI, the last Byzantine emperor, who turned it down due to cost. Eventually, the gun was built for the Ottoman Sultan Mehmed the Second, who ironically used it during the siege and fall of Constantinople in 1453. It is said that 90 oxen and 400 men were needed to transport the cannon to Constantinople.[2]

The 15th century also saw the spread of firearms to individual soldiers. The designs changed over time, from the arquebus to its successor, the musket, which appeared in the 16th century. The early firearms were clumsy, heavy, had a low rate of fire and an even lower accuracy. In many ways, the longbow remained the superior weapon for centuries. And yet, firearms quickly spread through all of Europe. Armies of the period, in particular during the 16th and 17th centuries, were characterised by a mix of ‘traditional weapons’ (e.g. pikes) and the new firearms. One of the main tasks of the pikemen was to protect those with firearms, as can be seen in the battles of the English Civil War and the Thirty Years’ War. By the 18th century, this mix had given way to armies that were fully equipped with muskets. Considering the weaknesses identified, the spread of the early firearms might look surprising, but there were clear reasons for their success. The first was money. Early firearms were expensive, but the proto-industrialisation in Europe from the 17th century onwards and the standardisation of weapon design and durability made them

more affordable. In addition, the mechanics of handling and firing a musket were easy to learn and did not require years of training.

This had far-reaching consequences not only for the tactical action on the battlefield, but for the structure and composition of armies. Up to this point, armies had consisted of three groups of people. The first was the aristocracy, which saw warfare as its raison d'être. The second, a specialist group of trained craftsmen, which, in many ways, were the decisive component of an army. This group encompassed different trades and weapons, for instance artillery and the longbow. The last group was that of untrained – or at least badly trained – men, usually peasants, who would often fight with their agricultural tools and simply made up the numbers (and suffered the highest casualties). The spread of firearms would make the last group in its original composition obsolete. By equipping this group with firearms and training them appropriately, the not overly effective masses would now become the main component on the battlefield. The fact that large groups of soldiers could be equipped with firearms was also one main factor for the increase in the size of armies from the 18th century onwards. The weapon systems allowed the French to raise and equip the levée en masse in 1793, which resulted in a French army of approximately one million men. The French Revolutionary Wars and the wars of Napoleon would have been unthinkable without this development. This change also saw the advent of the operational level of war, as Andrew Sharpe explains in more detail in his article in this special edition of *The British Army Review*.

While the basic skills of firing a musket were easy, the characteristics of the smooth-bore firearm required new levels of drill and tactical behaviour from the units on the battlefield. Due to the weapon's low accuracy, massed fire was essential to have an effect on the enemy and led to the development of the line formation. Tactical surprise often gave way to a methodical preparation and a meticulous line-up of troops prior to the battle. Breaking the line was considered a cardinal sin and advancing towards the enemy in a slow march became the norm. In order to drill soldiers accordingly, it was now recognised that troops needed to stay with the colours for long periods of time. This was a contributing factor to the spreading of standing armies in Europe, which had begun in the 17th century.

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Quickly the question arose as to how to maintain such standing armies. It proved too expensive for the states to rely on condottiere (as in the Italian city states until the 16th century) or mercenaries. One obvious solution was the increased drafting of soldiers from the home state. By the end of the Napoleonic Wars, most continental European armies relied on conscripts to fill the ranks in order to match the troop numbers that the French could put in the field. In line with this development (and linking back to the ideals of the French revolution and the levée en masse), the German army reformer Gerhard Scharnhorst stated that "the citizen is the born defender of his country".[3] This opened the doors for constitutional reforms. To put it simply: a citizen must fulfil the demands of the state (i.e. in this case, join the colours), but this, in return, gives him the right to become an active citizen of the state with the right of political participation. This was one of the main factors for the Prussian reforms of the early 19th century. In the military realm, these reforms introduced conscription, ended the nobility's privilege to join the officer corps and abolished the purchase of commissions in the army. The essence of these reforms is often seen as a main factor for German military effectiveness in the 19th and 20th centuries.

This vignette started with the invention of gunpowder and the subsequent invention of the firearm. From here, these innovations quickly moved into other areas, some of which are seemingly detached from the pure military arena. This shows that the development of new technology can have far-reaching consequences. If understood and utilised correctly, these changes and consequences can have positive effects far beyond the tactical level and even the military sphere.

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[1] *Cocroft, Wayne, Dangerous Energy: The Archaeology of Gunpowder and Military Explosives Manufacture, Swindon 2000.*

[2] *'Entscheidung am Bosporus', in Geo Epoche vol 56, Das Osmanische Reich 1300-1922, pp. 28-47.*

[3] *Donald Abenheim, Bundeswehr und Tradition: die Suche nach dem gültigen Erbe des deutschen Soldaten, Oldenbourg 1987, p. 210.*

WITH LEGS, NOT BAYONETS

AUTHOR

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THERE have been times in the long evolution of war that circumstances, rather than technological advances, or ethical changes, or tactical innovations, have led great captains down a certain path that, although perhaps not initially through deliberate design, have given them an edge over their opponents. At first such circumstances can seem to place nations, armies and/or their leaders at considerable disadvantage. But it is often through the confrontation of disadvantage that the most inventive steps are taken. Obvious advantage can lead to complacency and a lack of creativity. Apparently overwhelming disadvantage, on the other hand, can lead to innovative thinking. Those who are able to confront such disadvantage, and seek ways around it that nullify its effects, sometimes find in their actions new ways of conducting military affairs that, for a time at least, tip the balance in their favour. Seeing the opportunity in such moments, and turning these circumstances from one in which the previously overwhelming threat is converted into circumstances in which a new and as-yet-undiscerned-by-others advantage can be exploited by the sharp-witted, is a skill that can deliver what we describe in the jargon of the military world as 'force multipliers'.

As context, I offer a brief and unsatisfactory summary of European war-making for well over a thousand years, but it serves its purpose to illustrate the point that follows. For much of Europe's warlike history, and certainly since the Romans had ceased to be an all-controlling power up to the fifth century, warfare in Europe had been conducted in a fairly standard fashion. Unresolved clashes in strategic interests had led nobles, or royal families, to resort to armed force as a way of settling differences. Campaigns had been characterised by: the stating of grievances (real or manufactured); a mutual gathering of military strength; a movement of armies (or, sometimes, navies) to seek a place of tactical advantage; and a resolution (or attempted resolution) of differences on the tactical battlefield. In this scenario, the idea of a military campaign was to get opposing forces either to a point where the adversary was forced to concede without fighting a pitched battle (often using non-battlefield tactics – sieges and chevauchées and the like, aimed at the enemies' strategic interests), or to a place of battle where courage, tenacity, weight of numbers, and superior skill-at-arms and tactics could be called upon to defeat one's opponent and force terms. The 'campaigning season' was generally that time of year, after winter and the planting of crops and before the autumn harvest, when weather made the conduct of war easier (with less rain and mud) and large numbers of troops more available (because yeoman and peasant levies were available to fight rather than to harvest). If strategic differences remained unresolved at the end of the campaigning season, they were re-addressed in a similar fashion either

the following season, or, later on, when one side or the other perceived renewed tactical advantage. This résumé, although horribly general, is a useful characterisation of the accepted conduct of European war in the broadest sense for a very long time. The upheaval in late 18th century France changed all of that.

The French Revolutionary Wars (which took place over ten years between 1792 and 1802) and then the Napoleonic Wars (from 1802 through to 1815) marked a significant change in how Europeans came to conduct (and, later, think about) warfare. It was circumstances, rather than intention, that brought about this significant shift in military affairs. The French Revolution of 1789 caused turmoil in the traditional governance of Europe. European states, big or small, had been governed for centuries by noble dynasties and powerful royal or aristocratic families. During three-and-a-half years of extreme disorder after the outbreak of revolution in 1789, the Bourbon royal family was ousted, the throne toppled, the King executed (in January 1793), and France, arguably the most populous, largest, and most powerful state in Continental Europe, became a republic. Rule was now 'by the people', not by an elite. And not only had this centuries-old order been overturned, but it had been overturned in the bloodiest and most unpleasant of ways. The monarchies and dukedoms of Europe looked on in horror and could see nothing but disadvantage (nationally) and threat (which was, of course, for the leaderships of the rest of Europe, a very personal threat) from such a state of affairs. Thus Europe united in its opposition to France. Instead of being able to identify specific strategic goals, muster the necessary force, and march out during the campaigning season to confront an enemy, or a coalition of enemies, in a single seasonal campaign, France found herself confronted by enemies on every border and front, simultaneously and urgently bent on her destruction. For the rest of Europe, France needed to be defeated as a power, and revolution defeated as an idea. For France, this fight was existential, omnipresent and constant.

Initially France dealt with this threat in two ways. First, rather than adopting the more usual view that it is every government's duty to protect its citizens, Revolutionary France turned the concept on its head and proclaimed that it is every citizen's duty to protect the state. (This unusual philosophical approach persists in France to this day.) This allowed the military mobilisation of French manpower on a grand scale – manpower equipped, as we see elsewhere in this publication, with easy-to-use, mass-produced firearms that meant that massed armies could be raised and made militarily effective in a very short space of time (as long as they had the right tactics and the right moral component motivation – such as revolutionary zeal). Second, equipped with this mass manpower by the levée en masse of its population, France fielded multiple independent armies to deal with its multiple problems on multiple fronts. (And, conveniently, in terms of domestic politics, these multiple armies served the nascent and troubled peoples' government well, because they could, if necessary, be used to counter or to balance each other. A single very large army, under the command of a single individual, on the other hand, could confront and overthrow that tenuous government.)

"By 1804 Bonaparte had taken advantage of a short period of peace to re-evaluate how France might conduct this existential war, seeking to turn an unthought-through reaction to necessity into a considered way of war, by design and for advantage."

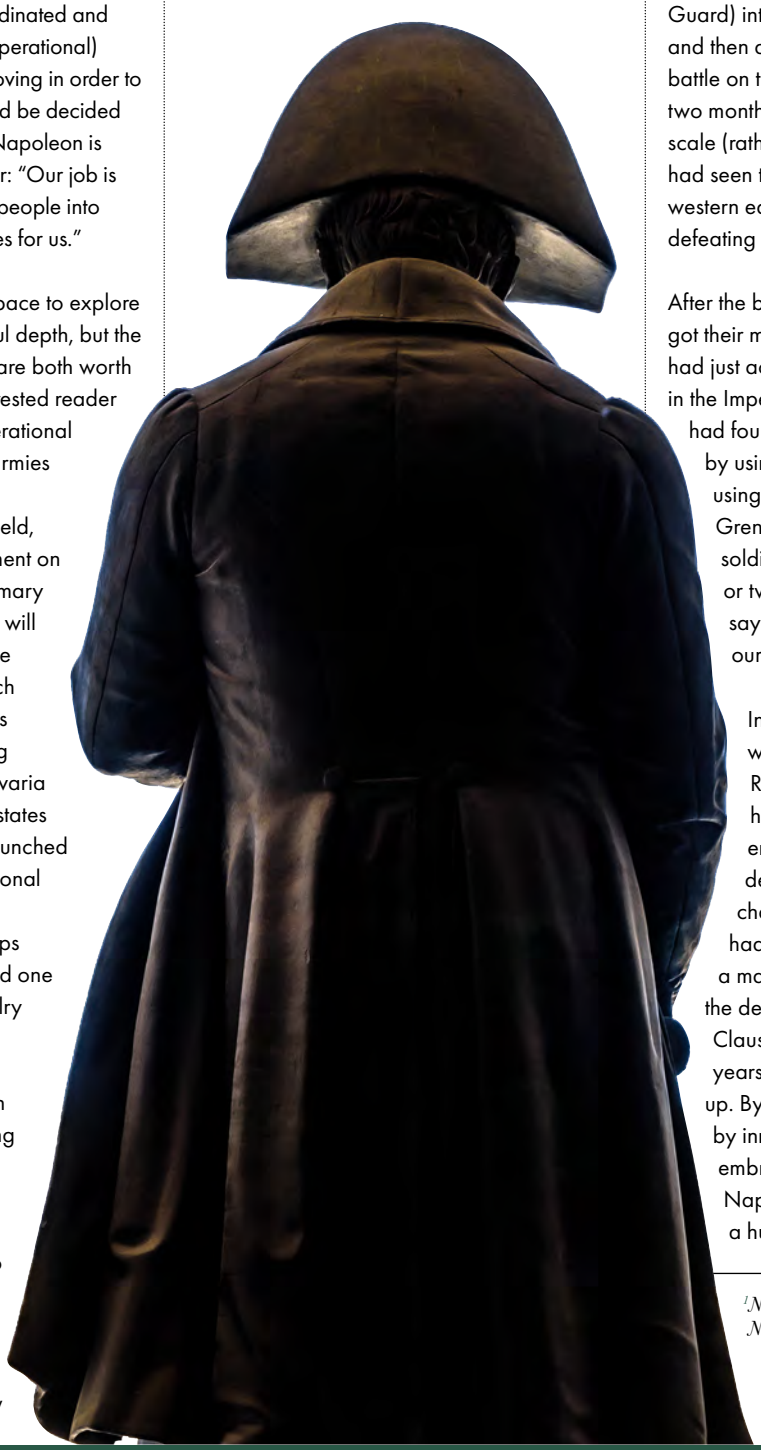
By 1802 Napoleon Bonaparte had brought the internal turmoil of French political wrangling and divisions to a close, first by his appointment as 'Consul for Life' and then in 1804 by crowning himself as Emperor. This absolute power also gave Bonaparte unity of command of the entire French army, but it did not remove the threat, or perceived threat, from all sides in Europe, despite the Treaty of Amiens (1802) that had brought a degree of peace. By 1804 Bonaparte had taken advantage of a short period of peace to re-evaluate how France might conduct this existential war, seeking to turn an unthought-through reaction to necessity into a considered way of war, by design and for advantage. With the French Grande Armée camped in Boulogne ready to invade the last overtly hostile antagonist (Britain), Bonaparte completed a reform of both structure and doctrine that turned the problem of war on multiple fronts in a 'constant state of campaigning' from threat and disadvantage, to one of military dominance on a continental scale. How?

First, he instituted the corps system throughout the Grande Armée. Building on the series of independent armies of the Revolutionary wars, Bonaparte formalised a system of mini armies, each commanded by a marshal or general, capable of independent action, but unified under his single command and the control of an able chief of staff. These corps would 'march divided' but, where necessary, unify to 'fight united'. Second, he conceived a new approach to campaigning – an approach that

we now consider to be the basis of operational art. Enabled by a combination of more mobile logistics and living off the land, Napoleon simply imagined tactical manoeuvre on a grander scale – the ultimate 'big hand, small map' approach. He substituted, in his method of fighting, a single march to a point of tactical confrontation (in the old style), to a grand manoeuvre by multiple marches that kept the opposition on a constantly unbalanced back foot, dividing forces, preventing enemies from concentrating, inflicting defeats in detail and aiming to allow grand tactical engagements to occur when his divided corps could unify for best effect by 'marching to the sound of the guns'. Third, he instituted a proper, organised, chief-of-staff and operational headquarters system, led by his able right-hand Marshal Louis-Alexandre Berthier, to cope with the new demands of making sure that the movements of this group of corps, manoeuvring at scale over 'small maps', would remain coordinated and focussed on the campaigning (operational) targets, rather than merely on moving in order to get to places where matters could be decided by tactical engagement alone. Napoleon is said to have observed to Berthier: "Our job is not to win battles, but to put our people into places where they can win battles for us."

This article does not allow the space to explore his campaigns in any meaningful depth, but the Austerlitz and Jena campaigns are both worth exploration in detail by the interested reader as prime illustrations of this 'operational level' manoeuvring, defeating armies not just through superior tactical engagement on a single battlefield, but through coordinated movement on a continental scale. A brief summary of the Ulm/Austerlitz campaign will serve to illustrate the point. At the end of September 1805 a French army of more than 210,000 was camped at Boulogne. Perceiving Austrian intentions to coerce Bavaria and other more minor German states to oppose France, Napoleon launched a lightning campaign of operational manoeuvre involving ten corps. Deception plans ate up two corps (one remaining in Boulogne, and one throwing out wide-spread cavalry screens well to the north of the main effort, to simulate massed movement in that direction), with two more committed to operating in Italy to tie down potential opposition from the south, while Napoleon speed-marched six corps across France and on into Wurttemberg and Ansbach on the Austrian border,

"By turning threat into opportunity, by innovating ahead of his rivals, by embracing change instead of resisting it, Napoleon had given his Grande Armée a huge advantage."

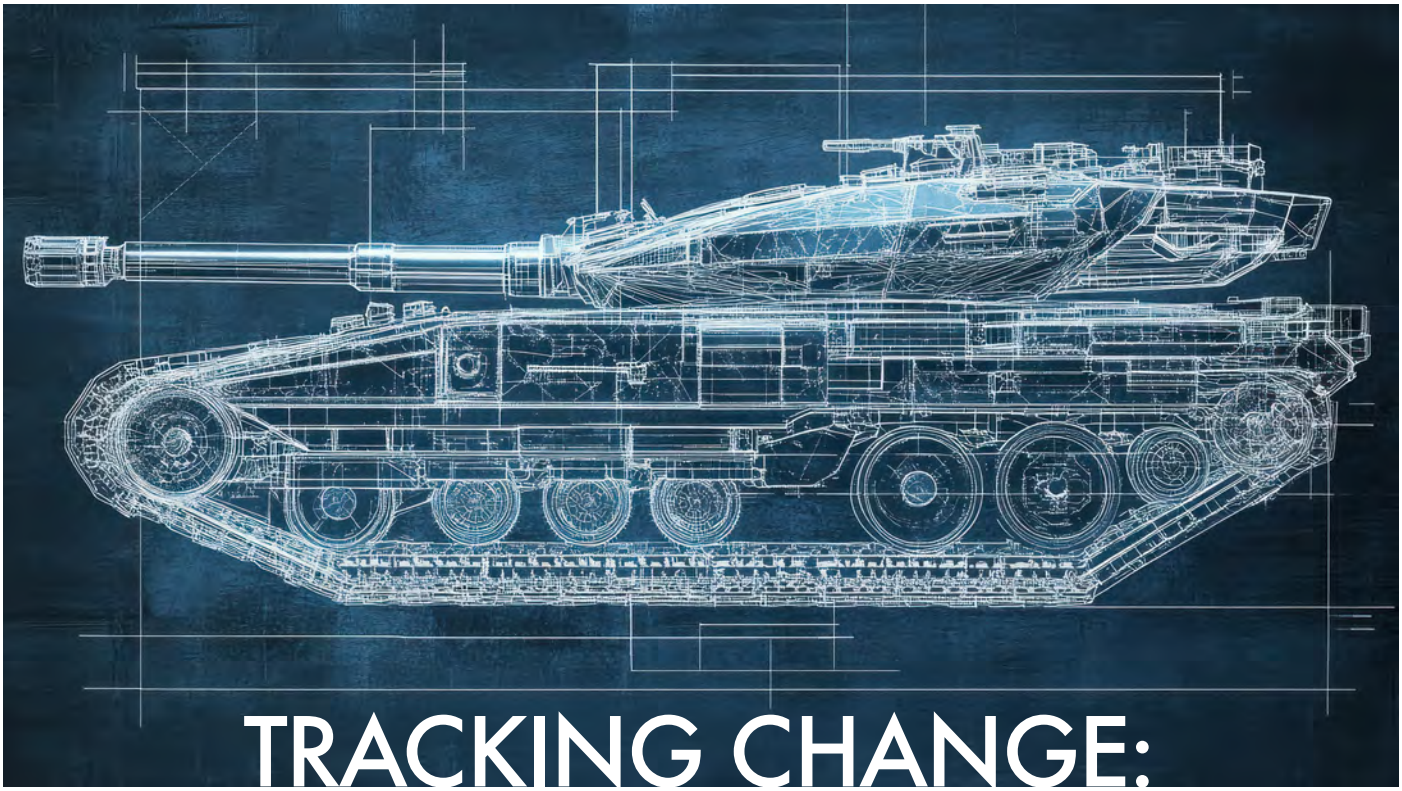


completing this feat in less than two weeks. By the 15th of October a number of minor engagements and at least two significant battles had been fought (with independent actions by the corps of Ney and Murat) resulting in Austrian defeats, and the remaining Austrian Army of some 70,000 men under General Mack surrounded and cut off in the city of Ulm. By the 20th of October 'the unfortunate General Mack' surrendered his army, depriving Austria and her ally Russia of a huge resource. Pressing on to see the campaign through to a strategic conclusion Bonaparte (and Berthier) continued with the grand-scale manoeuvre, arriving at Austerlitz (in the modern-day Czech Republic) just over a month after the victories around Ulm. Confronted by the combined armies of Austria and Russia (numbering over 85,000), Napoleon manoeuvred around 70,000 men in five corps (six if one includes the Imperial Guard) into a tactically superior position and then defeated them in a single decisive battle on the 2nd of December. In just over two months, a campaign of out-manoeuvre at scale (rather than simply tactical engagement) had seen the decisive force move from the western edge of Europe to its eastern borders, defeating three enemy armies en route.

After the battle of Ulm, as the French troops got their minds around the scale of what they had just accomplished, the jest of the moment in the Imperial Guard was that the Emperor had found a new way of waging war, not by using his soldiers' bayonets but by using their legs. As Captain Coignet of the Grenadiers of the Guard observed: "The soldiers were required to march eighteen or twenty leagues a day. They used to say: 'Our Emperor makes war not with our arms, but with our legs!'."[1]

Instead of resisting the challenge of war on multiple fronts at scale, as the Revolutionary Governments of France had done before him, Bonaparte embraced the problem and re-designed his way of war to turn challenge into advantage. Necessity had driven him to 'do war differently' in a manner that, post Waterloo, required the detailed study of reformers such as Clausewitz, over a period of several years, for the rest of Europe to catch up. By turning threat into opportunity, by innovating ahead of his rivals, by embracing change instead of resisting it, Napoleon had given his Grande Armée a huge advantage.

[1] *Notebooks of Captain Jean-Roche Coignet; Fourth Notebook; Section: Battle of Ulm/Vienna.*



TRACKING CHANGE: GERMANY AND TANK WARFARE

AUTHOR

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THICK fog blanketed the German position at Flers-Courcelette on the morning of the 15th September 1916. Poor visibility, however, could not disguise the fact that British troops were about to launch an attack. At around 8am, as the veil over the Somme began to lift, the Germans watched their enemy advance across the devastated landscape of no-man's land. In the case of the Bavarian 7th Infantry Regiment, the British approached in dense columns, supported by 20 to 30 aircraft.[1] This was not an unusual sight, but the two creeping metal structures that accompanied them were. The Germans did not know what to expect of these new additions to the battlefield, but they would quickly learn, as their efforts to slow the metal beasts (or 'dragons', as they were dubbed in an after-action report) with small arms fire proved futile. The first line of defence was swiftly broken and the advance could only be halted at the second line. Panic spread and some German soldiers fled. The Germans at Flers-Courcelette had just been exposed to the first tank attack in history, and a new chapter in the conduct of war had begun.

The assault did not achieve a breakthrough and the Germans, despite suffering heavy casualties, were able to hold the line. On the British side, technical teething problems hampered the use of the tank and coordination with the infantry did not always go smoothly. Of the 36 tanks that assembled on the 15th September, a maximum of 27 (the figures are debated) were able to take part in the fighting; the others broke down before they could reach the German lines. Nine of these tanks were destroyed by the Germans. But these issues were addressed by the British and just over a year later, in November 1917, they managed to breakthrough the German defensive line during the battle of Cambrai with a massed deployment of tanks. This was, arguably, only one of two occasions on the Western Front when an army was able to achieve such a breakthrough against a well-prepared enemy (the other one being during the German offensive in March 1918).

The tanks used in these battles were unwieldy. They were big, heavy and underpowered. They crept across the battlefield with a top speed of six kilometres per hour, which often dropped to a mere two kilometres on the difficult terrain of the battlefield. And yet, the tanks made a difference. Originally designed as mobile fire-platforms, their role was clear: to support the infantry and to give direct fire-support to the advancing troops. After the breakthrough was achieved, these tanks would become relatively useless in the exploitation phase of the operation. For this purpose, different tank models, lighter and faster, were soon developed. The French plan for the offensive in 1919, which did not materialise due to the German surrender in 1918, was based around

[1] *Walter Beyer, and Erich Scheitza, Königlich Preußisches Feldartillerie-Regiment Nr 221, Berlin 1933, p. 98.*

a large tank force of approximately 2,000 of these dragons.

Immediately after the battle of Flers-Courcelette, the Germans began to analyse what they had just experienced. The 6th Army quickly became the authority on the new weapon and the effect it had on the German troops. Interestingly, its report from 6th October 1916 concluded that the main threat had not been the mobile fire-power afforded to the British troops, but the psychological and moral toll the tanks had on the German soldiers: "The vehicles had, indeed, presented the Englishmen [sic] with some advantages. The main aspect was the surprise. With every technology, the unknown has the greatest effect, and this was also the case here. At first, the troops disregarded or even laughed about the monsters that were creeping forward. When they kept advancing, seemingly indestructible, they caused panic in some areas."[2]

In response to this analysis, the Germans spent a great deal of time and resources on training their troops accordingly. Consequently, the 'tank-shock' was overcome quickly, and the value of the tank was being questioned by some military personnel on both sides. The fact that German industry was overstretched and that raw materials were not available in enough quantities to build up a large tank force also contributed to the doubts as to whether the tank would be a real game changer. By the end of the war, only 24 German tanks had been built. Nevertheless, the appearance of the new weapon had a direct effect on the combat effectiveness of the combined German arms. Within field artillery batteries close to the front-line, one gun was often designated the anti-tank gun, which meant that its primary role was no longer fire support for the infantry. After the first attack at Flers, a number of guns were also sent to 1st Army in order to strengthen the defence against tanks. These comprised 20 navy guns, 15 trench guns from the war ministry and two trench guns detachments (with five guns each) from the 6th Army.[3]

"It was the intellectual engagement with the new means of warfare that prepared the German Army mentally and doctrinally for the next war."

The Treaty of Versailles reduced the German Army to a mere 100,000 men with no modern equipment: tanks, aircraft, modern artillery and other weapons were forbidden. By the standards of the day, the German Army thus resembled a paramilitary police force and not a modern army. What looked like a disaster for the German military turned out to be a blessing in disguise. With the physical component of fighting power severely restricted, the Army had to invest heavily in the conceptual component. As a consequence, the inter-war period was one of the most intellectually stimulating periods of military history for Germany's armed forces. This also included the theoretical interaction with tanks and tank warfare. The importance of this was made clear as early as 1923. In the main service regulations of the Weimar Republic, the Führung und Gefecht der verbundenen Waffen, or FuG, the then head of the Army, General Hans von Seeckt, stated: "Only if we keep alive the memory of those means that have been taken from us (aircraft, heavy artillery, tanks, etc.) will we be able to be victorious in a fight against an enemy equipped with modern material – even if we are lacking this material." It is therefore not astonishing to see that an entire chapter of the service regulations was devoted to tanks and armoured vehicles and their use on the battlefield – although the Army did not possess a single one of these platforms. The same approach can be seen in the subsequent regulations, the Truppenführung, which became the main regulations for the Wehrmacht in the Second World War. When it was issued in 1933, the Army still did not possess a single tank but, yet again, an entire chapter was devoted to them.

In addition to the pure theoretical approach, the Germans tried to gain practical experience. They attempted to outmanoeuvre the terms of the Versailles Treaty by opening a secret tank warfare school in the Soviet Union. It existed between 1929 and 1933 and a number of famous generals of the Second World War were trained there. But this was not enough to train and educate the entire Army – only a dozen or so officers were sent to the tank school per year. More important for the wider

understanding of the use of tanks was the incorporation of them into exercises and war games. But how could this be achieved under the restrictions of the Versailles Treaty? The solution was cardboard: structures resembling the silhouettes of tanks were placed on cars (and sometimes even bicycles). Reports from international defence attachés who attended such exercises highlight the disbelief and amusement registered when they saw these 'tanks' driving across the training areas.

And yet, it was the intellectual engagement with the new means of warfare that prepared the German Army mentally and doctrinally for the next war. It did not matter that the 'tanks' consisted of cardboard; what mattered was that the Army was able to develop a coherent concept of how to use the tank once the restrictions of the Versailles Treaty would have been lifted. Rather than putting their heads in the sand, the Army concentrated on developing the conceptual component of fighting power, making best use of what little was available to them. This took many forms. For instance, the developments of other nations were closely monitored and frequently discussed. This even happened openly, mainly in the *Militärwochenblatt* weekly, which offered a platform for debate and the exchange of views. The pages of the magazine were filled with articles and opinion pieces by senior officers and those who would become known during the Second World War, including such names as Guderian and Manstein. These thinkers opened the door to a new form of warfare. It would be wrong to state that this development was linear and without tensions and quarrels. Similar to other countries, traditionalists clashed with the more progressive minds. The role of the tank was hotly debated: was it a mere infantry support weapon or should it be used as a means of exploitation? What did this mean for tank design? However, the discussion quickly took a different path compared to countries like France or Britain. Here, the clashes between traditionalists and progressive minds were even stronger than in the German military. Cap-badge rivalry and the need to think about a peer-on-peer war as well as colonial warfare made it difficult to decide on a right path.

> **"The victories of the Wehrmacht in the early years of the Second World War were the consequence of the intellectually rich period of general military restriction during the inter-war period. Embracing change while future opponents were hampered by cap-badge rivalry, dreams about a return to colonial warfare and other factors gave the Germans the upper hand when war broke out in 1939."**

The fact that the Germans were not allowed to maintain an Army with modern equipment was a blow, but it also meant that they were unencumbered by the slow development of (and using of resources on) legacy equipment. This also enabled the Germans to develop new doctrinal concepts, which would go hand in hand with modern equipment once it had been acquired. The concentration of tanks in a tank division, rather than attaching them to infantry units as support weapons, was one of the concepts and it can be seen as one of the decisive factors for the German successes in the early stages of the Second World War. For instance, during the 1940 campaign in the west, the Wehrmacht had a force of 2,439 tanks concentrated in ten tank divisions. These stood against 4,204 allied tanks, many of which were better armoured and armed than the German tanks.[4] However, the concentration of the Panzer divisions in the Schwerpunkt of the operation enabled the Germans to achieve local superiority. This was enhanced by the successful conduct of combined and joint warfare, which the Germans had identified as a battle winner in the inter-war period.

The victories of the Wehrmacht in the early years of the Second World War were the consequence of the intellectually rich period of general military restriction during the inter-war period. Embracing change while future opponents were hampered by legacy equipment and thus thinking, cap-badge rivalry, dreams about a return to colonial warfare and other factors gave the Germans the upper hand when war broke out in 1939. It is interesting to note that this advantage was, first and foremost, based on conceptual and intellectual interaction with the new challenges and opportunities. It is thus the conceptual component of fighting power that needs to be the starting point when we debate the advantages of new technologies and equipment. Embracing new technologies and embedding their advantages into the conceptual framework offers ways to enhance every army's fighting power, be that the German Army of the inter-war period or the British Army of today.

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[2] *HGr Rupprecht, vol. 43, Akt: Fremde Berichte, p. 24, AOK 6, IA, Nr. 70450.*

[3] *HGr Rupprecht, Vol 117, Akt: 177, pp. 118-119, HGr Rupprecht IA Art I 749 g.*

[4] *Karl-Heinz Frieser, Blitzkrieg Legend. The 1940 Campaign in the West, Annapolis 2005, p. 56.*

AIR POWER: 'THE BOMBER WILL ALWAYS GET THROUGH'

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BEFORE air power, the British way of warfare involved maritime control of the sea, which allowed land forces to be transported and landed unimpeded to tackle the centre of gravity. Add to this the potential for blockade, a means of preventing access to critical raw materials, whilst also being able to secure firm rear and forward bases. In combination, this generally provided the means for either compelling an opponent into submission by the threat of joint warfare or military defeat when it was put into practice. Movement and engagements were, however, limited by geography, terrain, weather and logistics. As with nuclear submarines, it was the Second World War and an existential threat that forced the rapid development of technology and thinking which, for the most part, allowed these limitations to be minimised. The emergence of effective air power brought with it the means to provide critical support to the prosecution of the land campaign. Having served throughout the Second World War with key roles in the Battle of Britain and the Normandy invasion, Air Marshal Sir Thomas Elmhirst was well placed to comment on the effectiveness of air power. Speaking in 1947, he believed that while it had "a negligible influence" on the outcome of the 20th century's first global war, on its own it could claim half the credit for final victory in the conflict that followed.

Air power was still in its infancy in 1939, it was only 35 years since the first powered flight of a heavier-than-air machine. Except for the reactive and often hesitant experiences of the First World War, it required Anthony H. Fokker's further technical innovation – gearing an aircraft's machine gun to fire through its rotating propeller blades – and inter-war experiments (notably in the Spanish Civil War) to increase its lethality and advance air power from a largely reconnaissance role. The Italian theorist Giulio Douhet, with his *The Command of the Air* (1921), proposed the creation of an independent air force and advocated strategic bombing as a decisive tool for attacking an opponent's industrial and population base to destroy capability and morale. The Royal Air Force's first Chief of the Air Staff, Hugh Trenchard, also believed in attacking enemy infrastructure and morale, stressing the value of the offensive use of air power and maintaining air superiority through continual pressure. Both influenced the inter-war development of long-range bombers, shaping Second World War doctrines, and there was certainly a conviction that this was a military innovation that had to be embraced. Here was seen the potential not just to change war but to determine the outcome. Not intended as an endorsement of this new weapon system, in the British case, Stanley Baldwin's 1932 warning to Parliament that "the bomber will always get through" nonetheless highlighted the sense of urgency which existed. This was a clear threat – or opportunity – and when the response eventually came, a late 'crash' investment programme set out both to develop effective platforms, the Spitfire and Hurricane being standout successes amongst other procurement failures, while also creating a sophisticated ground-based gun using proximity fuses and a radar air defence system. Employing a defensive philosophy that did not negate air power's influence, what was not yet clear was how it could become pivotal and potentially vital for securing victory; at the most basic level, as one air historian has put it, "the British Army went to war without adequate

air support" or any real understanding of air-land integration, weaknesses which persisted throughout the war's opening years.

New ideas and the resulting new platforms that followed took some time to understand and operate to best effect, even when faced by an existential challenge. Speaking post-war, Elmhirst was able to explain what six years of intense fighting had revealed and offered for the future: "...for the imposing of a will on an enemy at the beginning and throughout a war there is now a new weapon in a bomber striking force that, once air superiority has been gained, can go across seas and frontiers and, if it is in sufficient strength and has the range, can get at the heart of an enemy country, while ground and sea forces are still only touching the extremities of the limbs of that country". Baldwin and those around him had identified the 'what' but it took the crucible of war to confirm the 'how' and even then not everyone emerged on the other side convinced of the 'cult of the bomber'. The debate about an over-reliance on strategic bombing and its failure or success was still to come and, in 1947, for

"...for the imposing of a will on an enemy at the beginning and throughout a war there is now a new weapon in a bomber striking force that, once air superiority has been gained, can go across seas and frontiers and, if it is in sufficient strength and has the range, can get at the heart of an enemy country, while ground and sea forces are still only touching the extremities of the limbs of that country."

Elmhirst, a highly experienced practitioner who recognised the value in identifying and learning lessons, it was much more the battle for air superiority which had proven vital. From 1944 once it had been achieved, this allowed "the most flexible weapon of the war" – the bomber (and by extension fighter bomber) – to restrict command and control, destroy communications and fuel and ammunition reserves and attack any massing enemy forces restricting what little enemy movement remained possible to darkness. Even overlooking that the enemy was fighting on multiple fronts after several years of high intensity conflict which had already resulted in considerable destruction of manpower and equipment, the eventual effective co-ordination of Allied air and land clearly played a considerable role in securing final victory.

In any study of how weapons are developed and employed, there is great value in considering the differing approaches and Elmhirst also noted how initial German success had depended on air power: the German Blitzkrieg relied heavily on air power to bomb enemy defences and support fast-moving tanks, overwhelming enemies before they could react. Rapidly won air superiority in Poland, which destroyed command and control and communications and prevented Polish forces from concentration; air superiority and the innovation of airborne and air-landing forces, which proved critical in overwhelming the Dutch and later the Norwegians while preventing British attempts

to interdict movement; and the threat of the terror bombing of major cities lacking anti-air defences, which encouraged quick armistices in Denmark, Belgium and France. From these conclusions the argument can be extended that a reliance on technological innovation needs to maintain its own tempo and momentum. As with the use of submarines, discussed elsewhere in this issue of *The British Army Review*, in many respects as the war persisted there remained no lack of conceptual ambition but this went unmatched by the highest level support needed to turn an idea into a capability. The Luftwaffe oversaw the development of the first jet-powered combat aircraft – the Messerschmitt Me 262, which entered service in April 1944 – and experimented with rocket-powered aircraft such as the Me 163 Komet, capable of high speeds and altitudes, and radio-guided bombs, such as the Fritz X and Hs 293, which were successful in hitting Allied shipping. Faced by limitations in resources, including fuel, trained pilots and production, none were deployed in sufficient numbers to have a meaningful impact and the potential advantage offered through technologically inspired vision was lost.

This was not repeated during the Cold War as the victors of the last war capitalised on what they had learnt and what they could extract from the impressive technological advances made by their adversaries. Since the war-driven advancement from infancy to become Elmhirst's conflict determining weapon system, air power has established a decisive presence in the conduct of war. Today military aircraft can be deployed rapidly and in numbers, much more so than any other force, and can strike anywhere in the world to reinforce allies and amplify the effectiveness of ground and naval forces. Air strikes can cripple enemy industry, infrastructure and logistics and, although he was focussed on the effects on morale of a targeted civilian population, Baldwin's warning correctly anticipated the clear psychological impact of sustained bombing. The shock and awe bombing campaign in Iraq (2003) overwhelmed Iraqi forces before the main invasion even began. Strategic bombers and intercontinental ballistic missiles are critical for nuclear deterrence and provide global reach. Drones, AWACS [Airborne Warning and Control System] aircraft and spy planes offer a critical intelligence, surveillance and reconnaissance advantage allowing commanders to track enemy movements, assess battle damage and anticipate threats. Close air support offers ground forces immediate air support providing both overhead protection and enabling them to break enemy positions and move forward on a battlefield. Suppression of enemy air defences missions allow for uncontested air operations; securing air superiority and controlling the skies still means being able to deny the enemy the ability to manoeuvre. Continuing technological advances have produced stealth aircraft which allow for operations to be conducted in hostile environments with minimal risk to pilots while modern precision-guided munitions allow for surgical strikes on enemy targets greatly enhancing not just precision but also lethality.

"The cost of air power is massive, covering research, development, production, maintenance and operations. With its stealth, multi-role capability and networked warfare making it deadly against enemy aircraft, radars and ground targets, the F-35 Lightning II is the most versatile and (potentially) the most decisive crewed platform yet developed. A carrier-capable air dominance, ground-attack and reconnaissance platform combined, it is the most expensive military programme ever, with over 3,500 of them ordered globally."

Perhaps also reflecting a history of military use that has only recently passed the 100 year mark, an accompanying conceptual drive has continued with the aim of developing and delivering the maximum possible effect. John Boyd revolutionised air combat doctrine with his OODA loop [observe, orient, decide, act] emphasising rapid decision-making and adaptation. Network centric warfare, emphasising the integration of technology and information sharing to enhance decision-making and combat effectiveness, was heavily influenced by his focus on speed, agility and the psychological impact of operations. Applied in Operation Desert Storm (1991), John A. Warden III's 'Five Rings' model of strategic targeting – leadership, system essentials, infrastructure, population, fielded military forces – placed an emphasis on parallel warfare, hitting multiple strategic nodes simultaneously to cause systemic collapse and has remained hugely influential.

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Force, with its 2024 budget reportedly over £140 billion covering fighter, bomber, drones, satellites production and maintenance along with research and development costs, this is a small price to pay but it is an exclusive club.

Another key consideration is the requirement for both political and senior level support, across all the domains of a military organisation, to ensure air power remains central to the evolving battlespace. With the need for massive investment and competition for military budgets, irrespective of what the 2025 Defence Review delivers, amongst several key discussion points the future role of air power has been one of the most intense. As one writer has described it, by the later years of the Second World War effective platforms and structures existed but "personalities made [air support] work". Whilst Churchill was a long-time and enthusiastic advocate, it required endorsement from the most senior British and American land force commanders – Bernard Montgomery and Dwight Eisenhower – building on theoretical and doctrinal work within the senior Royal Air Force leadership, before it could genuinely prove decisive. As the lessons from Ukraine continue to be studied and the benefits of artificial intelligence and hypersonic weapons are widely imagined, an imperative will remain for unqualified support at both the highest political levels and from all of the Services. This is particularly the case in an emerging era of conflict in which, as is discussed elsewhere, the use not just of uncrewed platforms but low-cost versions which, when used in an integrated and co-ordinated fashion, appear to have the potential for considerable short-term impact on how wars are fought.

"While it has been argued that, in modern warfare, whoever controls the air usually wins the war and that air power acts as the ultimate force multiplier, the real question today is not that different to 1939. There is plenty of evidence about the 'what' but much less certainty about the 'how'."

In the 80 years since the war's end, air power has offered a decisive force projection advantage by enabling military planners the option to strike first, strike deep and strike fast. It can be said to have fundamentally altered the speed, reach and lethality of military operations. For those that can afford the cost, air power has come to offer the potential to deliver an unmatched strategic advantage providing control of the battlefield and rapid strikes. Countries with advanced air forces can project power anywhere in the world while precision strikes have meant the need for fewer ground troops. Despite the often enormous costs, it has been critical in terms of deterring rational opponents who recognised the potential destructive effects it can have both on military forces and civilian infrastructure. There are, however, questions to be asked about what has remained a constant peacetime challenge, the often short service life of aircraft which become obsolete quickly due to advancing technology. According to Major-General J.F.C. Fuller: "...tools, or weapons if only the right ones can be discovered, form 99 percent of victory... strategy, command, leadership, courage, discipline, supply, organization and all the moral and physical paraphernalia of war are as nothing to the high superiority of weapons – at most they go to form the one percent which makes the whole possible". But put another way by a more junior British Army officer writing in the 1960s: "The finest weapon in the world, like the most delicately constructed tool, is no more than waste metal in the hands of a bungler. On the battlefield, as in the factory, it is the skill of the craftsman that counts. For although war is fought with weapons, it is won by men." While it has been argued that, in modern warfare, whoever controls the air usually wins the war and that air power acts as the ultimate force multiplier, the real question today is not that different to 1939. There is plenty of evidence about the 'what' but much less certainty about the 'how'.

Whether considering the (effectively executed) German inter-war doctrine of the use of air power as a 'blitzkrieg enabler', or the wider (equally effectively executed) doctrine of 'the bomber will always get through' to attack operational and strategic centres of gravity, both (indeed all) schools of thought were faced with a, perhaps obvious with hindsight, foundational truism, once confronted with the realities of global all-out war. It sounds obvious, but the Second World War demonstrated, starkly, that air power is effective only if it can be used – air superiority, or preferably supremacy, is the deciding act, not the use of air that follows.

RISE OF THE MACHINES

"In the Age of the Almighty Computer, drones are the perfect warriors. They kill without remorse, obey without kidding around, and they never reveal the names of their masters." – ***Eduardo Galeano***

AS Andrew Stewart's article alluded to, technology can advance at a rate that fundamentally changes the way warfighters plan and conduct operations. Air power – in all its diverse glory – created tools and opportunities for planners that had, until then, been almost unimaginable; and it has been seen as a strategic necessity for militaries across the world to dominate or deny the skies ever since. The strategic axioms about air superiority, holding ground, manoeuvre warfare and depth in defence (to name but a few) all remain foundational elements of military strategy and are unlikely to change for the foreseeable future, but with the irresistible march of technology comes new ways of achieving these aims. It is with this in mind that we consider the impact and implications of drone warfare, and the inevitable reduction in – or potential removal of – soldiers from

combat as uncrewed systems start to dominate the modern battlefield.

The onset of drone[1] technology has been seen by some as a seminal moment in terms of warfare and how it is conducted. Throughout the war in Ukraine (which is the primary arena in which drone warfare is developing), the advancement and utility of drones across the spatial domains of the battlefield has been swift, climaxing (at least for the time being) with the tactical level use of drones in a combined arms assault in the Kharkiv region. This small-scale assault utilised drones as close air support, C4I [command, control, communications, computers and intelligence], reconnaissance platforms and as direct and indirect fire support, providing capabilities on the ground and in the air that would have historically been fulfilled by soldiers and aviators. The assault was conducted at a fraction of the cost of conventional action and with almost no risk to the attacking force. And while a drone-only offensive comes with, not insignificant, limitations, the ability to execute one demonstrates the increasing trend of using automation over human interaction, which reduces the risk to, and burden on, the military's most important asset – the soldier.

The use of drones by militaries is by no means new. From the Goliath tracked mine used by the Wehrmacht in the Second World War to the US Lightning Bug that conducted reconnaissance in Vietnam, drones have been used, albeit in small numbers, for the last 80 years. However, with advancements in miniaturisation, battery life, fibre optics and artificial intelligence, drones have become an integral part of the modern battlefield. The critical role of the Turkish manufactured Bayraktars in the sinking of the *Moskva*; the use of 'Dracarys' [so-called dragon drones] as deliverers of modern day napalm; the sinking of the *Tsezar Kunikov* by a sea drone and the aforementioned all arms operation conducted by the 13th National Guard Brigade in late 2024 are just some examples of how drones and drone warfare have left an indelible mark on the modern multidimensional battlefield. Moreover, to a country like Ukraine, which has faced a numerically and technologically superior force, their adoption of and then further adaptation to drones and drone warfare has had a significant impact on their way of warfighting, and it has helped keep them competitive.

At the tactical level, Ukraine has been able to offset some of its manpower and equipment shortfalls by heavily relying on drones to interdict assaults before they get close to the front line. Working in conjunction with artillery fire missions, they have improved the effectiveness and efficiency of defensive actions, reducing the exposure of combat personnel to risk and significantly easing the burden in terms of logistic manoeuvre and resupply demands. Recent use of drone hunters to intercept Orlans and other Russian reconnaissance drones has also reduced Ukraine's dependence on air and aviation to provide A2AD [anti-access/area denial], whilst complementing short-range air defence systems like the Gepard or Strela-10, which are high value assets and are in short supply.

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At the operational and strategic level, drones are also starting to impact the wider theatre of war. Whilst at the tactical level soldiers have complained about the psychological impact of drone warfare (akin to the German use of the JU87-Stuka siren during the Second World War), they have also been effectively used in psychological operations by the Russian Federation, with the nightly assaults on Ukraine's citizens and civilian infrastructure (not unlike The Blitz in 1940/41). Concurrently, the use of Ukrainian long-range drones has had a profound impact on the Russian people who, up until 2023, could have been forgiven for not knowing their country was at war with Ukraine. The Ukrainian drone raid into Moscow in September 2023 (Ukraine's own version of the 1942 Dolittle raid) provided a stark example of how drones have developed from tactically limited multi-role utility weapons into operational and strategic level deep strike capabilities (albeit with smaller payloads and success rates compared to ballistic and cruise missiles). The almost daily assaults by Ukrainian drones against Russian energy infrastructure have also had a strategic level impact on how Russia conducts its war; not only reducing Russia's ability to finance its 'special operation' but also restricting the availability of key fuel types to support the Russian offensive, whilst forcing the repositioning of critical air defence assets to protect these sites. Similarly, in respect of Ukraine's tactical level interventions, the use of long-range drones has significantly reduced the need for air and aviation to provide this capability (which arguably it would not have been able to achieve without suffering unsustainable losses) and is costing a fraction of the price and time it would take to manufacture and then deploy ballistic and cruise missiles.

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Outside of the Ukrainian theatre of operations, non-state actors are also utilising drones and drone warfare to advance their aims. Once the exclusive toy of powerful states, these systems are now frequently being used by terrorist organisations such as the Houthis, who have been able to successfully strike critical national infrastructure belonging to Saudi Arabia and have staged, albeit unsuccessfully, strikes against NATO warships. So what? Terrorist threats have ever been thus. But if we consider the recent mass drone sightings across the US in November and December 2024, when hundreds of drones were spotted across military bases, there is clear cause for concern. While these were just sightings, as opposed to strikes, the most powerful military in the world had no means of denying their visitors and the FBI was unable to establish the identity of the perpetrators; highlighting the apparent ease with which strategic locations can be reconnoitred – and potentially attacked – by such means. The ready availability of drones, and their increasing use in everyday, civilian life, also means that the number of agitators, non-state actors and hostile states capable of their effective deployment will continue to expand. Counter capabilities are developing at pace, but this arms race shows

[1] *The term drone is used to define all UAS/UGV/USV systems currently being used on the battlefield.*

no sign of slowing and the use of fibre optics, artificial intelligence and swarm technologies will further exacerbate the threat, making the defence of strategic locations more and more difficult. Yes, the impact to date of this kind of asymmetric warfare has been limited but as the IRA once stated in the aftermath of an attempt in 1984 to kill then UK Prime Minister Margaret Thatcher, "you have to be lucky all the time, we only have to be lucky once". Its arguable that the use of drones in asymmetric warfare is currently being overshadowed by their conventional use in Ukraine, but it provides irregular forces with a force multiplier and an operational reach they have seldom had outside of mortar rounds and unguided rockets.

So what does the future hold for drones and drone warfare? As militaries across the world start looking at augmentation and human interface with technology, drone technology finds itself at the very forefront of this work. In the last three years we have witnessed the evolution of drones from line of sight and small screen capabilities to a mix of heads-up displays, first-person views and virtual/augmented reality tools. This coupled with concepts like the 'loyal wingman project' should allow an individual to control multiple platforms simultaneously, which means we may, in the not-too-distant future, see swarm attacks orchestrated by small groups of personnel or even an individual soldier. And such mass matters – as the Germans discovered during the Second World War. Despite the Konigstiger tank representing the very pinnacle of German technological might (on the ground, at least) and capable of destroying, on average, ten Shermans for every loss to their own fleet, it proved not to be a battle winner. Why? Because unlike the extremely technical, expensive and quite exquisite Konigstiger, there were hundreds of cheaper and simpler Sherman tanks ready to take the place of those destroyed by the enemy. Similarly, drones can create capability mass in the event that conventional platforms and soldiers are scarce. As alluded to earlier, no one can accurately predict the future or the speed at which technology advances. However, it is highly likely that the attritional warfare currently being endured in Ukraine will continue for some time to come. And if that does prove the case, those planning and preparing for future confrontation but struggling to meet recruitment and retention targets, have a solution of kinds to the problem of mass. (Albeit this new mass currently still requires technologically skilled soldiers, trained to control, support or maintain its systems).

Noting that necessity and desperation breed innovation (as has been seen in Ukraine), we can expect the sophistication and exploitation of drone technology to continue to march on. Fibre optic drones, for example, were an unknown a year ago, but they are now rapidly becoming commonplace on the battlefield. It is unlikely we will see something analogous to Arnold Schwarzenegger's T-800 *Terminator* any time soon, but the ability to automate killing and provide machines with the intelligence to independently target already exists. It is not a huge leap to take and further removes the soldier from direct threat, so how long will it be until human and machine are entirely decoupled?

"It is unlikely we will see something analogous to Arnold Schwarzenegger's T-800 *Terminator* any time soon, but the ability to automate killing and provide machines with the intelligence to independently target already exists."

So how do we summarise this tour de force and its increasing influence on warfare? Our understanding of drones and their capabilities have, in the last five years, gone from exquisite systems providing bespoke capabilities to readily available and extremely cheap utility platforms dominating the battlefield. This does not mean drones will replace the common soldier or be able to take and hold ground, which is difficult enough to do with well-trained, vigilant troops, but they can provide capabilities that historically have required an individual or individuals to face risk (for example, close air support). They can also certainly reduce some of the burden and demands on front line soldiers by providing effective fire support, interdicting incoming offensives, evacuating wounded soldiers and resupplying the front line. Moreover, drones are providing units with the kind of integral capabilities and freedoms they could never have imagined five years ago, especially as Ukraine continues to evolve the role of drone units at battalion and brigade level.

Finally, while the artillery and the infantry remain the predominant forces on the battlefield, drones are undoubtedly competing for the title – they are responsible for more than 70 per cent of all casualties on the battlefield in Ukraine, according to the Chair of the Defence and Intelligence Committee in the Ukrainian parliament. Even if drones are unable to fully achieve the complete array of capabilities offered by the humble soldier, what they will achieve will cost less and demand less than the aforementioned and will certainly provide a complementary supporting capability to those forces. If the rapidity of drone evolution remains at its current rate, then their application in war is almost boundless and will further redefine how wars are fought.

If all of the above is so, then it will be those armies that seize the moment now (rather than waiting until they are in contact) that steal a march on their opponents. Replacing traditional unit wiring diagrams (full of people and vehicles) with orders of battle that include drones, at scale and in all shapes and sizes, may be a route to increasing combat power fast and at relatively little expense.

'UNDERWAY ON NUCLEAR'

SINCE the American Revolution and the launch of the Turtle in 1775 – which tried and failed to attach explosives to HMS *Eagle* – submersibles and submarines have provided a powerful example of military imagination and innovation and its potential to effect the battlespace. As many as 10,000 military submarines have since been built, half of these during a five-year period in the mid 20th century. Conflicts that have expansive, potentially unlimited aims which threaten existential outcomes to those involved can also have dynamic effects on how technology is refined and employed.

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The Second World War acted as a significant driver for the development and refinement of platforms that had exhibited their potential during the previous global conflict. With rapid advances in torpedo range, accuracy and reliability combined with an unrestricted use that ignored previous rules and norms relating to the conduct of conflict, submarines had an important role during the First World War. In 1939, however, they were really little more than submersible destroyers. Diving to escape counter-attack or in the latter stages following an attack in daylight, underwater performance was inferior to surface running. The manner in which they were used, often preferring to surface and fire their torpedoes or mounted guns, also meant they were not invulnerable: during the conflict one third of British submariners at sea lost their lives. Throughout the war's duration here was a weapon system which never proved genuinely decisive but demonstrated considerable potential, such as with the disruption caused by German U-boats to Atlantic shipping convoys. And, as Paul Lockhart concluded in his recent study of firepower, "the pinnacle of German U-boat technology, the Type XXI and Type XXIII Elektroboote (electric boats)" could have "wreaked havoc with transatlantic shipping, effectively shutting down the American-Canadian supply line", restricting or even halting the Allied land-based offensives in Europe. Lessons identified in combat combined with significant engineering and design leaps to create platforms that would lay the foundation for subsequent evolution on a major scale.

The antecedent of nuclear-powered submarines, everything about the Type XXI was new – from its powerful diesel-electric propulsion system to its streamlined profile. Its maximum surface speed of about 16 knots was not extraordinary but its submerged speed was exceptional – 17 knots conventionally and six knots with its engines in silent-running mode. The really innovative upgrade was that they were meant to operate submerged and could remain under water for around 75 hours, much longer than any other submarine. It also only took five hours to recharge batteries if the snorkel was deployed. Faster and quieter than any other similar vessel, with a range of more than 15,000 nautical miles, it could hunt as far as the east American coast with ease. Introduced in 1943, the intention was to build 1,500 with orders placed with multiple shipyards, but only 118 were completed and just two were put into active service although not used in combat.

Nonetheless, this was a pivotal point and a critical foundation on which to develop not just a possibly decisive platform and weapon system but a doctrine and culture which could build upon and exploit continuing technological development. As the leading maritime historian N.A.M. Rodger wrote, "there was a prospect, at once enticing and alarming, of building the first true submarines, capable of maintaining high speeds for long periods underwater". What made this all the more appealing was the wartime development of nuclear weapons, which appeared to have fundamentally changed how military force was employed. In thinking about post-war applications,

there was almost immediately seen to be an overwhelming military value in exploiting the advantages offered by presenting the enemy with 'independent decision-making centres' which, operating at depth underwater, could remain largely immune to the new threat whilst also carrying the means to respond in the most devastating manner. They carried the potential, particularly once subsequently armed with their own nuclear missiles which could be launched independently of any national command framework, to act not just as a strategic deterrent but also as unparalleled force multipliers.

'Underway on nuclear power', the signal sent by the first commanding officer of the USS *Nautilus* (SSN-571) on the 17th January 1955 as it departed her US base, represented the next step. Describing them as "the best insurance policy the nation ever had", Paul Kennedy has referred to what followed as the "silent and subversive... underwater battle of wits" and the "crucial confrontation of the Cold War". In the modern era, nuclear-powered but conventionally armed SSNs and the nuclear-powered and armed with nuclear intercontinental ballistic missiles SSBNs remain amongst the most potent global weapons systems. And, as the conflict continues in Ukraine and debate has once again focussed on the twin challenges of battlefield transparency and survivability, American writer Andrew Krepinevich has grouped them with uncrewed platforms, mobile missile launchers and special operations forces as "the most capable of operating in relative safety in a terrestrial no-man's land" as they "emphasize speed, mobility, stealth, or some combination thereof", reaffirming the military value they offer.

"[Submarines] carried the potential, particularly once subsequently armed with their own nuclear missiles which could be launched independently of any national command framework, to act not just as a strategic deterrent but also as unparalleled force multipliers."

Writing more than 30 years ago, the SSBN's unique package of characteristics was described by Royal Navy submariner Vice Admiral Toby Frere as the 'Seven Deadly Virtues'. He identified flexibility, mobility, stealth, availability, endurance, reach and autonomy as being what made them so potent and what made them, then and still today, extremely difficult to detect and counter. With what he termed as their "long legs", once at sea they have considerable independence operating quietly and at depth in an underwater third dimension. Following the inspiration of the Type XXI there has remained an emphasis on generating a speed greater than any potential quarry. Unlike conventional diesel-electric submarines, which still need to surface or snorkel to recharge their batteries, their reactors provide a high, sustained speed (often 25 plus knots) allowing them to outrun threats. This unlimited power source also means they can operate indefinitely and remain undetected far from their home base for months at a time. They can move quickly to forward operating areas and, with considerable freedom of action, have the potential to surprise an opponent delivering overwhelming effect. As autonomous and versatile platforms, they are able to switch between different roles and tasks with little notice. While nuclear missile equipped SSBNs with their invulnerable second-strike capability act as the strategic deterrent, the SSNs can perform a variety of missions,

including anti-submarine warfare and anti-ship operations, forward surveillance and intelligence gathering, special operations support, and land-attack missions using cruise missiles. Speed, agility, global reach and overwhelming firepower have made for a potent combination.

This platform also has a wider impact beyond its huge kinetic potential and the strategic deterrent value this provides. It has been argued that "its pre-eminent characteristic is the effect that it has on the military psychology... it has demonstrated its ability to instil fear, to divert disproportionate amounts of men and material to deal with it, and to shape the course of a campaign". As noted, one of the associated benefits is that they act as a significant force multiplier, a single nuclear-powered submarine can fix an opposing force – requiring huge resources tracking and countering them. Consider also the comments made in October 1960 by First Lord of the Admiralty Peter Carrington, following the launch on Trafalgar Day of the first British nuclear submarine, HMS *Dreadnought*. The former British Army officer referred to the beginning of a "new era" that demonstrated national capabilities and the "white heat of a new technological revolution", while media coverage made frequent reference to a "revolutionary" event which confirmed the "modernity" of the country's military forces. Being able to develop and employ weapons systems incorporating emerging and cutting-edge technologies reinforces national prestige and sets nations apart from those which possess only conventional platforms or none at all.

"Being able to develop and employ weapons systems incorporating emerging and cutting-edge technologies reinforces national prestige and sets nations apart from those which possess only conventional platforms or none at all."

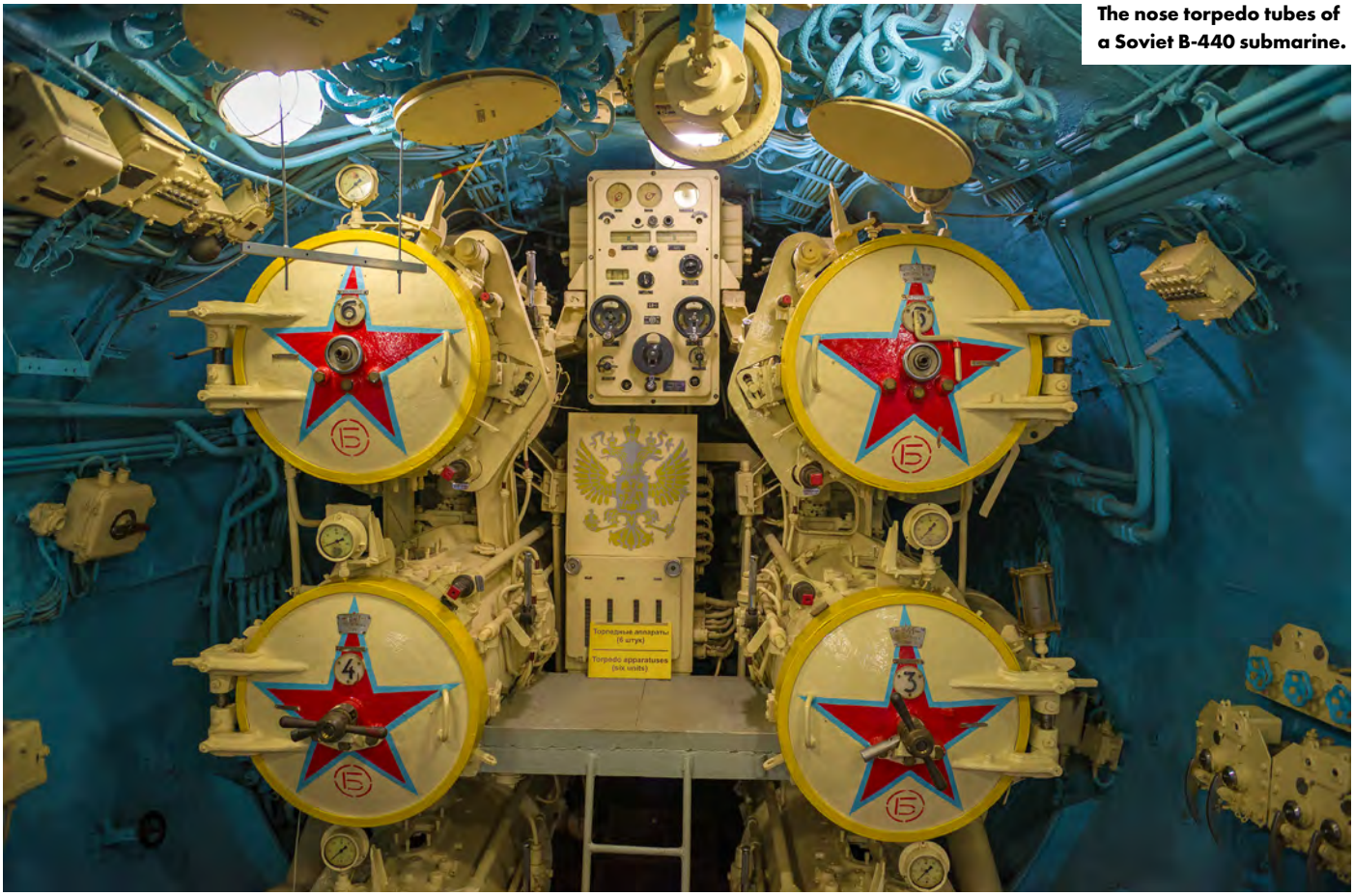
It must also be acknowledged that there are challenges associated with technology driven military change. Frere's conclusion was that "the endurance and self-sustainability of the nuclear submarine is limited only by the size of her larders". There was also a warning, however, of the need for "a core of professional expertise and experience, not just education but also culture and tradition". To build nuclear-powered submarines has required very high standards in engineering and a range of scientific and technical skill bases. Maintaining these vessels is just as demanding; as he went on to argue, and as has been demonstrated, once the skills are lost they are "seldom easily rediscovered". There are also the financial implications of a technology that could be described as exotic and bespoke in origins and design. Although with the range of tasks and missions

they can conduct, it could be argued that they are actually cost effective, nuclear submarines are expensive. The current cost of each of the Royal Navy's future Dreadnought class SSBNs – with figures fluctuating with continuing global fiscal shocks – is around £8 billion; ten per cent of this figure will cover the Challenger 3 programme and deliver nearly 150 upgraded tanks. Finally, while SSNs can make a much greater contribution with their range of roles, ultimately SSBNs are a strategic capability which depend on their deterrent effect; they cannot secure ground or win battles.

Nonetheless their attraction remains clear, over 450 have been built worldwide, around 40 per cent by the United States with Russia, France, Britain, China and India operating the others. Many of these have been retired due to age, treaty limitations or cost considerations and recent figures (2024) show a remaining global fleet of around 150 vessels, with the United States operating 68 and Russia having the second largest fleet with 29 vessels. There have also been recent attempts by Brazil and North Korea to join the group by developing their own. In contrast, there are more than 400 conventionally powered submarines in service worldwide. Since the 1960s, Britain has built 23 SSNs ranging from the Valiant to the most recent Astute class and eight SSBNs, the initial Resolution-class followed by the Vanguards; during the late 1960s and 1970s, the Royal Navy was building SSNs at the rate of one every 15 months. The UK's Continuous at Sea Deterrent, Operation Relentless, has functioned since 1969 and plays a key role not just in Britain's defence but also NATO's strategic planning. With six Astutes and four Vanguards currently active (and Dreadnought replacements for the latter under construction), growing media interest in the degree to which the SSNs are deployable has further highlighted not just the costs involved with maintaining advanced technology driven platforms but the impact this has on strained defence budgets.

"Nuclear-powered submarines provide a clear historical example for policy-makers as they consider new competing technologies and how they might be employed. With their durability, manoeuvrability and survivability they meet what should be three of the key requirements for investment."

Nuclear-powered submarines provide a clear historical example for policy-makers as they consider new competing technologies and how they might be employed. With their durability, manoeuvrability and survivability they meet what should be three of the key requirements for investment. And despite the huge financial costs involved, along with the requirement to develop and embrace an holistic approach to their adoption into military structures, they have allowed those states able to deploy them to do more with less, an ideal which should remain the over-riding goal. An existential conflict provided the conditions in which the basis for a genuinely revolutionary platform could emerge. But it would take an even greater threat, the Cold War and the potential it carried not only for global destruction but, more significantly in this context, a rapid and decisive defeat of opposing military forces, to advance beyond the conceptual to something that could be deployed. With a nuclear power source and nuclear tipped missiles, for more than 60 years there has been a platform offering reach, stealth, endurance, flexibility and overwhelming effect deterring a war between those great powers which operate them. Without the successful development and application of technology, there would be no nuclear-powered and armed submarines. The moment still needed to be seized to deliver a capability which, today, remains central to British defence planning and underpins grand strategic thinking.



The nose torpedo tubes of a Soviet B-440 submarine.

DEEPER THINKING NEEDED TO ENSURE UK DEFENCE IS NOT LEFT 'LAGGING' BEHIND

THE six articles so far offered in this *British Army Review Special* may lead readers to remark to themselves: "interesting discussion, and food-for-thought for sure, but 'so what', exactly, for the modern practitioner of the military art"?

First, at the CHACR we are firm proponents of the value of analysing history in order to uncover those unchanging elements of the nature of war that provide us with the foundation upon which we can build the superstructure that we feel will serve us best in coping with whatever the changing character of war has to throw at us. This retrospection provided us, the authors, with a series of linked thoughts that led to a central conclusion. History offers multiple examples of when circumstance (be it invention, context, technology, strategic drivers or simply an era of innovative thinking) has meant that change was either necessary or inevitable. Those saddled with expensive capability that is easier and cheaper to adapt, rather than to change out altogether, have tended to be those slowest to recognise the opportunity for advantage through radical change. And those who have resisted the change have lagged behind those who have embraced (and, even, exploited) it. The 'open-minded exploiters' have stolen a march on the 'traditionalists'. But looking back, alone, is not enough.

> **"If, as most of the serious thinkers engaged in the study of the Earth's climate suggest, the warming of the world will force change upon us, then resisting that change is not logical. Adaptation will have to happen, so the wise will embrace change, rather than resist it."**

Second, if, as most of the serious thinkers engaged in the study of the Earth's climate suggest, the warming of the world will force change upon us, then resisting that change is not logical. Adaptation will have to happen, so the wise will embrace change, rather than resist it. The more routine thinkers, in Defence, are looking at the problem and seeking solutions and contributions in terms of climate-change-mitigation. This is an approach pejoratively summarised as 'lagging the lofts in Bulford Garrison'. Such disparaging language, however, is not helpful. A full range of mitigation measures, such as 'lagging lofts', needs to be implemented if Defence is to play its vital role in climate change alleviation. But, we would argue, that is mere reactive background activity when set against the increasingly clear opportunities (rather than just threats) that this global climate context places before us.

We would urge readers to think of ways in which they can seize the moment (*carpe momentum* in Latin), and also generate a momentum in the modern English sense of the word, that might allow the contextual threats of climate change to be turned to considerable tactical and operational advantage. In short, in trying to deal with the downsides of this global context, the sharp thinkers, those thinking more deeply and broadly than their opponents, may find ways to double or treble their combat power in very short order – as the Chief of the General Staff would wish. Two final articles now follow, which, while providing no clever and polished answers, may offer those seeking avenues to find such advantage pause to reflect on the options that they may wish to explore and/or exploit.

FUTURE-PROOF? FUSING GREEN POWER AND FIGHTING POWER

AUTHOR

Dr Warren Chin has written extensively on the relationship between technology and the changing character of war and explored the implications of these in his latest book, *Technology War and the State*.

MILITARY futurology has become an increasingly hazardous exercise. Military planners are expected to anticipate the impact of potentially disruptive technologies and to comprehend how future enemies might utilise and exploit them. However, today this task is more complex because the military must also grapple with elemental environmental forces that will shape the future operational landscape. Of these, climate change is the most important. Climate-induced fighting in Syria, Sudan and the Sahel have reinforced the importance of climate change as a cause of conflict and provide some insight into the challenges the British military might confront in future operations. Even 'Blighty' is no longer safe in this increasingly dystopian world, and ongoing research highlights the negative impact of extreme weather events on the United Kingdom. To forestall the realisation of a future approximating the cinematic spectacle of *Mad Max*, successive British governments have supported measures to help limit the rise of global temperatures to 1.5 Celsius by reducing the emission of global greenhouse gases. Not surprisingly, there has been a demand that all government departments play their part in ensuring the realisation of this objective. Although Defence accounts for only one per cent of the UK's greenhouse gas emissions, it is also expected to comply with this requirement. The question is how far it can go in trying to achieve this objective and what impact will this have on its fundamental mission to defend the United Kingdom. Clearly, there are parts of the Defence estate where change is possible. Moreover, there is also a substantial financial argument to replace fossil fuels with cheaper and cleaner renewable energy sources. Most interesting, however, is the view of some within the Army who believe we can extend these measures to shape the creation of future operational capability, i.e. warfighting, by combining green power and fighting power.

This is a risky proposition, especially as the benefits of reduced greenhouse gases within Defence are likely to be tiny, but the costs, measured as the potential for military failure, are extremely high. As such, it is all too easy to dismiss changes of this ilk and remain with the status quo. However, this view neglects the possibility that a greener army might also be a more effective force. To make a crude comparison, if we look at medicine, numerous drugs intended to treat one condition have sometimes been found to have a profound but unintended effect on other diseases or ailments. A good illustration here is the Shingles vaccine, which appears to have an additional beneficial effect in reducing the chances of dementia. Is the pressure to make the fighting end of the Army

greener likely to lead to a more effective fighting force?

The answer to this question depends on what type of military mission is imagined. For example, a stabilisation operation conducted within a semi-permissive environment might provide an ideal setting to deploy a greener army. However, unless we can afford to create bespoke capabilities for specific missions like peacekeeping, which we cannot do, then the measure of success must be how effective a force will be if deployed in warfighting. What, then, are the claimed military benefits of developing a greener warfighting capability?

A DIFFERENT MILITARY REVOLUTION: HYBRID GREEN AND FIGHTING POWER

In exploring the argument in favour of a low-carbon army, the principal operational advantage of making such a change focuses on how this will reduce the force's logistical footprint, which ensures greater resilience in theatre and reduces its dependence on extended and vulnerable supply lines.

The most immediate problem lies in the reliance on the combustion engine to power most military vehicles. On paper, this problem is easily resolved by replacing existing petrol- and diesel-powered vehicles with electrically powered versions of trucks and armoured vehicles. How, then, will this fleet of electric vehicles be charged? A great deal of hope rests on the investment currently being made by the US military in the creation of micro-nuclear generators. The principal justification for this technology is based on the recognition that in any future war, American lines of supply across the Atlantic or Pacific will likely be cut, which means they will need a local source of power to keep their forces actively engaged. Having a small nuclear reactor deployed to support a brigade-sized force is one way of achieving this goal.

Developments in rapid charging technology and improved batteries will give armoured vehicles greater flexibility and range when conducting operations. In addition, such systems offer a feasible counter to the increasing number of surveillance systems on the battlefield. They are silent and so will not be detected by acoustic sensors, they also have a low heat signature which makes them harder to detect using thermal imaging. Most important, they have their own independent energy source to power up. Greater reliance on directed energy weapons will also lead to some reduction in the tonnage of ammunition needed to fight. In sum, on paper at least, the proposed changes look appealing on military and operational grounds. In addition, front-line military forces can use solar energy to power drones or to recharge equipment used by soldiers, for example, night vision goggles, laser rangefinders, targeting systems and radios.

However, it is also important to recognise that significant challenges continue to obstruct this revolution. First, the electrification of the army vehicle fleet might work but will be limited to vehicles below 40 tonnes in weight. Luckily, most of the Ajax family of armoured vehicles are just below this weight limitation and so can be equipped with batteries, but excluded from this list will be the future Challenger 3 tank, which is likely to be over 66 tonnes. The current state of battery technology is not sufficiently powerful to bear this kind of weight. Similarly, while the use of a mini nuclear reactor is an interesting innovation, the big problem is that such a power source will quite literally be a missile and bomb magnet for the enemy; burying it in the ground will, at best, delay but not prevent an attack against such a critical vulnerability. Finally, directed energy weapons are a viable technology that reduces the need for ammunition supply, but these weapons are very large and require lots of electricity. In addition, they also suffer from certain environmental limitations which can be exploited by the enemy. Finally, it is unlikely that this capability will be able to substitute for all forms of firepower on the battlefield that are provided by an array of large and smaller calibre guns, rockets and missiles. In sum, we currently have a lag between the aspirations implicit in this proposed military revolution and what is technologically possible. The next question, then, is what emerging technologies will become available over the next 20 years to facilitate the realisation of this vision?

LOOKING TO THE NEXT GENERATION OF TECHNOLOGIES TO SUPPORT THE SYNTHESIS OF GREEN POWER AND FIGHTING POWER

The technologies described previously are on the verge of becoming viable and usable products, but they also suffer from limitations which means the project of green power is a risky venture. But if we look over a longer technological timeline, can we identify key emerging technologies which will facilitate the achievement of a more effective fighting force that is also green?

One possible alternative to the mini nuclear reactor is to invest in the development of giant solar balloons that can remotely charge ground-based systems and weapons. These giant airships will be five kilometres in size, will be covered in solar panels and will be deployed 40 kilometres up into the atmosphere, where they will synthesise the power of the sun to create 100 kilowatts of electricity. Harvested solar electricity will be transmitted through wireless microwave beams to a receiver on the ground. Alternatively, the energy can be stored in a battery, which can then be dropped and deployed when full. Giant solar balloons are currently being tested by the Defense Advanced Research Projects Agency, and it is claimed that the Chinese are also working on this technology.

But how, then, do we deal with the challenge of ensuring all armoured vehicles are electrically driven? Of specific importance here is the tank. Currently, creating an electric tank that is comparable to its diesel-powered counterpart would require the addition of five tonnes of batteries! Even if it was possible to fit a smaller battery that could store the energy required, there is still the problem of range. A conventionally powered tank has an

approximate range of 500 kilometres before requiring a quick 'petrol stop', but in the case of an electrically powered tank, the distance it could cover on a single charge would be 150-250 kilometres, and it would take hours for the batteries to recharge making it vulnerable to attack.

There is, however, an alternative solution. A smaller, lighter tank is possible by removing the human crew from the system and automating it. We are partially on this path, as the Russian Armata demonstrates with its autoloader and crew of three. But why not remove the entire crew and rely on artificial intelligence (AI), which, in effect, creates a lethally autonomous system? The question is how long it will take to develop AI so that it can be safely employed in this setting. Today, AI is capable of only conducting single tasks, for example, playing chess, but lacks the understanding to engage or make sense of the wider world beyond the activity it was designed to master. This is an important limitation in the land domain, which is characterised by complexity and, therefore, limits the application of what is termed narrow AI. The next big evolution in this area is artificial general intelligence (AGI). This represents a level of intelligence that is equal to or even higher than that of a human. Some remain sceptical that AGI will ever happen; others argue it is likely to happen in the next 20 to 40 years, but certainly, it will be in place by the end of this century. Our arrival at this moment is called the Singularity – a concept used in relation to black holes, a phenomenon where the natural laws of science break down. Precisely the same breakdown is expected when AI surpasses the intelligence of its creators. As such, it is an emerging technology which cannot be ignored.

"Artificial general intelligence will allow both land and aerial systems to be used as swarms both to defend and attack. Behind the operation of these systems will be a keen intelligence able to instantly process vast quantities of data and direct these systems to attack at a speed no human intelligence can compete with. In addition, it will also never tire, it does not experience fear, and its span of control will extend beyond our traditional levels of command, the battalion, the brigade, the division, the corps and the army, allowing it to command and coordinate vast numbers."

While the precautionary principle provides clear guidance on why it is important not to pursue the development of AGI, I suspect humanity will ignore this because of the perceived benefits accruing to those who build it. This is particularly true in the realm of war, where states are constantly seeking a competitive advantage against potential foes, and AGI promises a great deal in the generation of a state's fighting power. AGI will allow both land and aerial systems to be used as swarms both to defend and attack. Behind the operation of these systems will be a keen intelligence able to instantly process vast quantities of data and direct these systems to attack at a speed no human intelligence can compete with. In addition, it will also never tire, it does not experience fear, and its span of control will extend beyond our traditional levels of command, the battalion, the brigade, the division, the corps and the army, allowing it to command and coordinate vast numbers. In sum, humans will no longer have a decision-making role in the conduct of operations; the pressure to win will force human decision-makers to delegate control to their AGI, which will be more than capable of coping with the complexities of the land space. Looking over the horizon at the next 40 years, one cannot help but wonder if a combination of declining population, increasing fiscal constraints and the perceived political convenience of using metal, not flesh, on future battlefields will determine the land environment becomes heavily automated in this way. Politically, at least, it creates a form of deployable military power that can pack a punch. How, then, might we supply this heavily automated force? In the case of air and sea assets, this is less complicated as they will find it easier to sustain such forces from their home base. The real challenge focuses on the land domain: How does a state sustain battles that might be waged at super levels of intensity, even if only for short periods of time?

One possible answer lies in the emerging

area of nanotechnologies. Nanotechnology is defined as 'the understanding and control of matter at dimensions of roughly one to 100 manometers where unique phenomena enable novel applications.[1] It means working with objects that are a thousand times smaller than a human hair and allows us to build anything, atom by atom. Today, nanotechnology is used in a variety of different areas. For example, it is transforming certain areas of health care by allowing targeted delivery of drugs using nanoparticles that target only cancer cells, which has led to a dramatic fall in the side effects experienced during chemotherapy. It is also being used to facilitate the miniaturisation of electronics by making transistors at the nanoscale. As a result, while the size of electronic devices will shrink, they will be significantly more capable.

It is also playing an instrumental role in the transformation of materials technology. At the nanoscale, carbon nanotubes and graphene are 200 times stronger than steel but are much lighter. Such innovations could be extremely useful in the production of armour for both vehicles and personnel. Indeed, the Defense Advanced Research Projects Agency and United States Special Operations Command worked on the development of an *Iron Man*-style suit for the US military. The suit contained a liquid that hardened on impact to protect the wearer from bullets and other forms of ballistic damage. Known as Talos, it is one of a number of research programmes sponsored by the military intended to make body armour lighter while increasing the level of protection offered. Looking further into the future of nanotechnology it is anticipated that it will be employed to mass produce small scale military robotics, drones and surveillance devices. These will be integrated with AI. Consequently, nanotech will lead to the deployment of smaller and better protected systems that pack more 'bang for your buck'.

Looking 40 to 50 years ahead, nanotech may well play an instrumental role in making war obsolete. The scientific historian James Burke speculated that the emergence of this technology would revolutionise not only the scientific realm but also society, politics, economics and, most importantly, war. If we can build anything from atoms, including food and materials, then we are looking at an age of abundance replacing an age of scarcity. He called this invention a nano fabricator and explained the easiest way of understanding the groundbreaking nature of this concept is to think of it as the replicators used in the science fiction series *Star Trek* – these look like mircowave cookers but they can produce anything. With this capability, the problem of supply disappears for the ground formation and this has huge implications for the conduct of operational art.

This then brings us to the final area of innovation required to bring about a green military revolution, which focuses on the human interface with future war machines through the science of human enhancement. If humanity is to have a role in this future battlespace, soldiers will need to be enhanced both physically and cognitively. This means capitalising on the current investment being made in a range of areas. Some of these, for example, nanotech armour and exoskeletons, have already been discussed. However, the latter will be vital if soldiers are to start using man-portable directed energy weapons, which will be considerably heavier than the current range of small arms employed by infantry. In the cognitive domain, a range of nootropic drugs are currently available to improve cognition, but their effects are still unproven. Moreover, such measures will not be sufficient to allow humans to interface with AGI on the battlefield. This will require a more dramatic intervention in the form of brain-computer interfaces. These can collect and analyse signals from the brain and send signals to it. Currently, this technology exists in the form of a headset or can be achieved by the insertion of invasive implants into the brain itself. For example, an implant developed by Neuralink has allowed a paraplegic to operate a computer with his thoughts. In the future, it should be possible to use neural implants to allow disabled people to move artificial limbs. Neuralink is also developing an implant to restore sight. In the long run, the company wants to increase humanity's mental powers, and it hopes brain-computer interfaces can be used to connect human brains to AI and massively augment reasoning and knowledge. In China, scientists claimed to have developed the world's first non-invasive two-way brain-computer interface, allowing a drone and human pilot to communicate with one another. A brain-computer interface also means soldiers will have to carry less heavy weaponry as they can call on fires from deep from their rear. This, too, eases the connection between front and rear lines of operation.

The idea of a green military revolution, as briefly touched upon here, could radically alter our understanding of contemporary operational art by giving a new lease of life to the offensive and the conduct of ever-deeper operations by ground elements able to break away from their lines of supply. However, like theories of Soviet deep battle or airpower in the inter-war period, the technological foundations of this revolution have not yet matured sufficiently to allow the realisation of this vision. Finally, it is important to recognise that while this technology frees fighting formations from their lines of communication, it relies on materials and technologies that will have to be imported from sources which might not be reliable in time of war. This requires government to think about a technology and industrial strategy that addresses these deficiencies. As such, the pursuit of a greener army could have far reaching consequences for wider policy beyond Defence.

[1] *US National Nanotechnology Initiative, nano.gov*

ENHANCING ARMY LETHALITY THROUGH SMARTER ENERGY MANAGEMENT

AUTHOR

Major Paul Goodall is an armoured infantry officer currently assigned to the Royal United Services Institute as the British Army's Visiting Fellow.

"The electrification of the battlefield to the point where every soldier carries electronic equipment has greatly improved the ability to coordinate land formations and situational awareness, and therefore the tempo and lethality of land forces."[1]

MODERN military operations are more dependent on electrical energy than ever before; largely a reflection of the digital transformation of the battlefield which, in turn, mirrors the global digital age. As the British Army continues to integrate more advanced technologies, from artificial intelligence-enabled warfare to quantum computing and manufacture, operational reliance on efficient and sustainable electricity becomes paramount, not least because technological integration enables the 'any sensor-any effector network' needed to deliver the exponential increase in lethality demanded by the Chief of the General Staff at the 2024 Land Warfare Conference. Sustainability in this sense has nothing to do with environmental concerns, but solely the maintenance of assured resources used to generate the power demanded by military operational activity. This article will describe the capability advantages from increased 'battlefield electrification', then argue that to fully exploit current and emerging technologies, the British Army should adopt more effective strategies for managing electrical energy on operations. Not doing so will leave us unprepared for any future energy transition imposed on the operational environment and fail to utilise the technological advantages inherent to such a transition.

ELECTRIFICATION IMPROVES SURVIVABILITY AND ENHANCES LETHALITY

Contemporary combat operations have served to remind us that survivability is directly linked to lethality in modern warfare. In a sensor saturated environment where adversaries maintain persistent strike capability within an expanded contact zone at the fighting echelon, reducing friendly force emissions across the spectrum, both acoustic and electro-magnetic, is critical to survival. The current high demand for electric power by equipment, whether mounted on or separate to platforms, is almost entirely generated by combustion engines in vehicles or static generators. The consequent noise and heat produced identifies these vehicles or locations – such as headquarters – from the signature generated, which can then be targeted. Minimising this signature, by reducing operating time or through alternative means of electricity generation, will therefore increase survivability.

[1] *Watling, Jack and Sylvia, Noah (2025) Competitive Electronic Warfare in Modern Land Operations, RUSI, p1.*

Furthermore, technological advances in areas such as active camouflage are made easier if the original emission source is reduced.

The British Army has successfully demonstrated the use of directed-energy weapons, including a laser system capable of destroying drones.[2] The adoption and integration of defensive aid suites, whether designed to counter enemy uncrewed aerial systems or anti-armour missiles, further highlights the need for a robust battlefield electrical infrastructure. These systems require power that under current configuration is inefficiently generated and distributed. Without a holistic approach, the demand for ever greater amounts of electricity will be met by further inefficient use of additional multi-spectral 'noisy' combustion engines, thus reducing any improved lethality by not considering the survivability of platforms and equipment. Arguably heavy formations with large numbers of vehicles in the fighting echelon that can generate 12 or 24V power from almost every platform will be able to meet the power demands of the electrified battlefield, for now at least. The issue is more acute for light forces who are also equipped with power consuming devices, including remote autonomous systems, but currently lack sufficient means to generate electricity to recharge those systems. A recent Defence Science and Technology Laboratory study concluded there will be an increase in power demand for soldiers using enhanced capabilities in a remote autonomous systems-enabled battlegroup. The future force will be equipped to be more lethal but generating the power it needs through extra hydrocarbon combustion engines risks survivability and has significant logistical consequences.

Hybrid and battery electric vehicles have operational advantages through the reduction in overall fuel consumption but also the key benefit of near silent operation, thus improving stealth and reducing vulnerability to enemy detection. This was proved by Project Lurcher and Technology Demonstrator 6 trials along with other automotive and tactical advantages of diesel-hybrid platforms.[3] It is important to acknowledge that electric vehicles – whether a battery electric vehicle or fuel cell electric vehicle – are not completely silent and are decreasingly so at higher speeds; mechanical noise and heat is still emitted, especially from running gear on tracked platforms, however, electrification provides an edge when combined with sound tactical application. In static locations, a lightweight field generator employed at an HQ to provide electrical power (consumed by communications equipment and the recharging of the multitude of different batteries used by the associated force element) has a signature characteristic for that location. If alternate procedures for use were adopted, enabled by equipment procurement, the benefits of quieter, more efficient operations at a headquarters could be realised. Even if contemporary battery technology and the programme maturity of the Army's next generation of 'heavy platforms' mean that hybridisation of Ajax, Challenger 3 or Boxer may be unlikely, electric power options for lighter platforms should be considered by capability and acquisition teams, including the potential for future hybridisation. In the near term, the next generation of generators should be replaced by quieter 'smart' systems, already commercially available, that continuously trickle-charge a battery bank, thereby reducing noise and providing stored power for peak demand periods.

"Generating electricity comes at a significant logistical cost, with implications from the sub-tactical to strategic. Battlefield electricity is currently almost entirely derived from hydrocarbon combustion. Therefore, if operational electricity is managed more efficiently, for example by generating only for the required consumption, storing excess power and distributing within a tactical network, the volume of hydrocarbon fuel will be reduced."

SMARTER ENERGY MANAGEMENT UNLOCKS ADVANTAGE THROUGH REDUCED LOGISTIC BURDEN

Generating electricity comes at a significant logistical cost, with implications from the sub-tactical to strategic. Battlefield electricity is currently almost entirely derived from hydrocarbon combustion. Therefore, if operational electricity is managed more efficiently, for example by generating only for the required consumption, storing excess power and distributing within a tactical network, the volume of hydrocarbon fuel will be reduced. The potential is significant, as noted by the former Chief of Defence Support and Logistics, General Richard Wardlaw, in a fictional letter

[2] *Defence Equipment and Support, 'British Army fires drone-destroying laser demo weapon from armoured vehicle', 11 Dec 24, des.mod.uk/british-army-laser-wolfhound-drones.*

[3] *Acceleration; improved torque; potential for reduced electronic signature; reduced crew fatigue among others.*

written in 2032, that forecasts the release of combat power previously needed to protect the logistic tail supporting diesel generator farms using three million litres of fuel a year. He also references the historical example of 60 per cent of the casualties taken in Iraq and Afghanistan being from those protecting logistics convoys.[4] Operational advantage can be achieved by reducing the fuel needed by the forward echelon, both in terms of overall volume and the flexibility to reduce packet sizes that increase survivability through dispersion and redundancy. The benefits from reduced logistic demand in a combat environment characterised by pervasive threat of adversary sensor and strike assets would be attained from the fighting echelon backwards. At the tactical level, electrification enhances force survivability and lethality, and generates advantages operationally through the potential to reduce logistic demand.

The means to achieve the advantages laid out are not nested in science fiction, but in the application of commercially-available technology applied to the military context. It is not a fantasy of miniaturised nuclear reactors for every vehicle platform or a call for electric main battle tanks.[5] Micro nuclear reactors, hydrogen, 'green power', synthetic fuels or another form of electricity generation may one day replace hydrocarbons in a global or military energy transition, but in the near-term commercial-off-the-shelf technology is available that can deliver the advantages outlined. Our current reliance on outdated generators and alternators in vehicle platforms underscores the inefficiencies inherent in our existing methods, but changing the current fleet due for replacement at the end of this decade is only part of the solution. The foremost issue to overcome is the organisational process and cultural approach to managing battlefield electricity.

The challenge in adopting a more efficient approach to battlefield electrification is not purely technical, but foremost procedural and to a certain extent cultural. Modern military operations demand a cultural shift in how we manage and deploy electrical energy on the battlefield. In their home environment personnel are accustomed to using portable power banks, electric vehicles and mobile charging stations, yet the Army fails to regard electricity as an operational commodity. A change is needed so that electricity is recognised as a critical commodity that must be managed in the same manner as hydrocarbon fuels, or even the same approach to ammunition as a resource. Currently, the British Army generates and consumes electricity but does not effectively store or distribute it, particularly in dynamic operational settings. This approach is particularly limiting in operational environments where static power infrastructure is typically absent. Even in fixed locations, the emphasis remains on direct consumption and redundancy; consider the approach on major HQ exercises where every tent has a generator and often a back-up generator. A reimagined approach to electricity management involves efficient generation and the thoughtful conservation of power resources, from the smallest battery in a weapon sight to our largest systems. Drawing a parallel to established principles in electromagnetic spectrum management, some re-learned from previous epochs, where emissions are minimised and outputs shielded to enhance operational security, we must adopt similar strategies for electrical power.

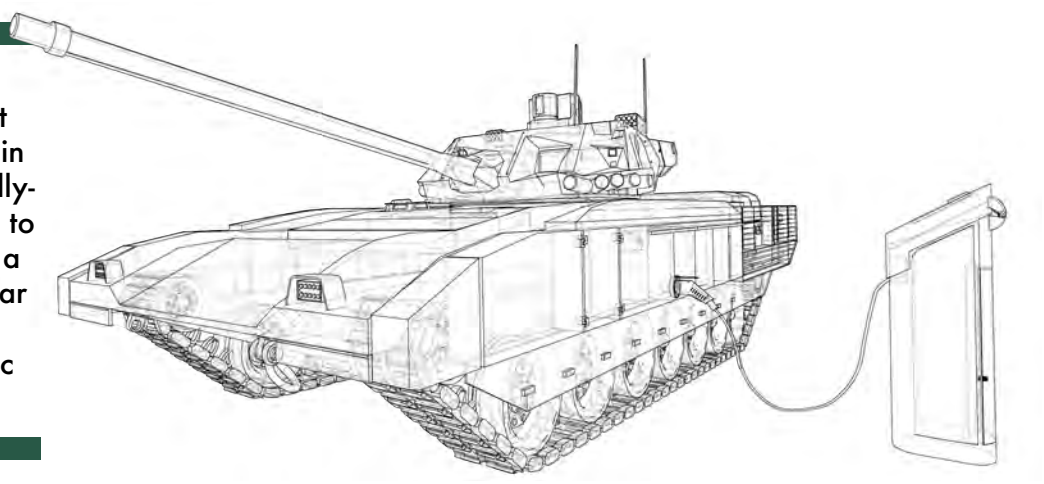
History shows that having to 'learn' to manage a new commodity is not new. Less than a century ago the USA switched transportation modes from horsepower to combustion engines in a process that studies report as taking up to 50 years. Similarly, managing electrical energy efficiently will require doctrinal adjustments, training modifications and capability investment in power storage and distribution technology. The Army is already starting to adapt; Project Spinneret research on an Allied Rapid Reaction Corps exercise showed that with a relatively small battery bank and consideration for 'demand management' rather than prioritising absolute reliability, the current inefficient use of generators could be greatly improved. Collective training activity that logistically constrains exercising troops by only allowing them to draw on resources taken into the 'box' should also enable the concept of electrical energy planning.

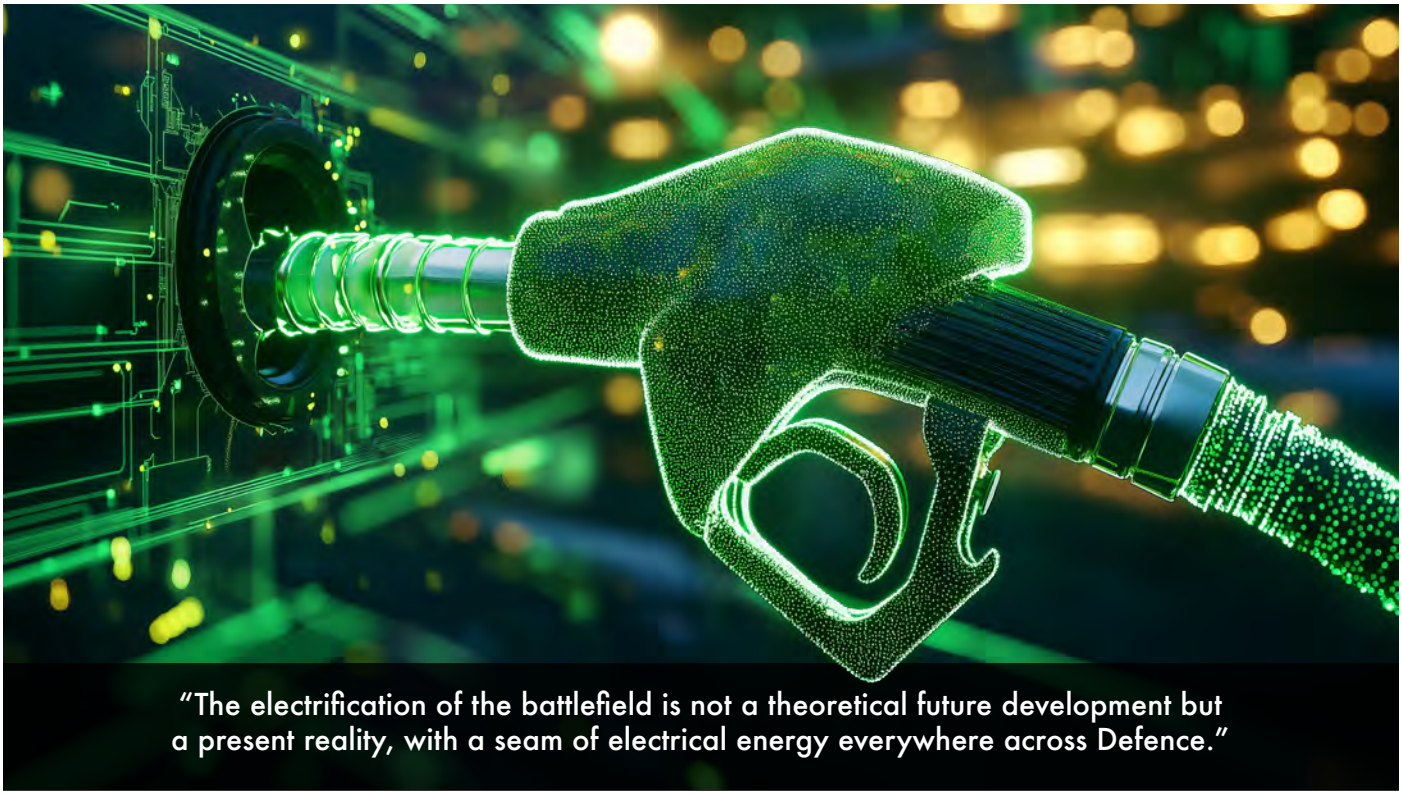
Reimagining and proactively adapting the extant system to treat electricity as a commodity will not only enable more efficient power generation but will allow further expansion for its use in future technology. Developing a new energy management system that reflects the demands of the contemporary battlefield and is constructed in a manner that enables it to evolve with further energy transition and emergence of technology is key. It enables nearer term transition to hybrid or battery electric vehicles and supports the procurement of equipment drawing electrical power. It also prepares our operational structures for adoption of future alternate power generation, such as micro-nuclear, should they occur. Finally, it builds resilience into operational structures subject to potential future macro pressures to divorce from current reliance on hydrocarbons for economic or geo-political reasons. Defence may be forced down a path not of our choosing, but by engaging with the issue from the perspective of operational energy, the tactical needs of the force are more likely to be protected. Future battery technologies will be pivotal in this transition where advances in energy density, power-to-weight ratios and charging capabilities are key to unlocking military use cases that do not rely on rare

[4] *UK StratCom, 24 Aug 23, 'Sustainability – how to achieve operational advantage'. Available at: gov.uk/government/news/sustainability-how-to-achieve-operational-advantage, accessed 7 Apr 25.*

[5] *Power to weight ratio remains the issue. A study from the US forecast unlikely to have electric armoured vehicles before 2035. South Korea has aspirations for a hydrogen fuel cell electric vehicle main battle bank operational in 2040.*

"The means to achieve the advantages laid out are not nested in science fiction, but in the application of commercially-available technology applied to the military context. It is not a fantasy of miniaturised nuclear reactors for every vehicle platform or a call for electric main battle tanks."





"The electrification of the battlefield is not a theoretical future development but a present reality, with a seam of electrical energy everywhere across Defence."

earth metals with complex geopolitical and ethical implications.

RECOMMENDATIONS FOR A SMARTER APPROACH TO OPERATIONAL ENERGY

1. **Integrate electrical power management into operational planning cycles at every level:** Incorporate electricity management into mission planning to ensure power requirements align with operational needs and resource availability.

2. **Invest in commercial off-the-shelf technology:** Modern battery banks, smart generators and hybrid-electric platforms are readily available and can provide immediate benefits without requiring lengthy development cycles.

Aligned to specific training or operational activity, the use of this equipment should be seen as more than just 'trials' but a contribution to training and force development as part of a holistic change programme that will enable the effective integration of future technology.

Procurement is not of highly classified technical equipment, nor should the purchase be the 'final answer'.

3. **Train personnel in power management:** Soldiers and commanders should be educated on energy efficiency principles, to instil the treatment of electricity as a valuable resource that must be managed effectively. Doing this, enabled by the provision of 'tools' in the second recommendation, will develop 'techcraft' – "the marriage of field craft and technology".[6]

4. **Upgrade legacy platforms:** Retrofitting existing vehicles and systems with improved alternators and battery solutions will enhance energy efficiency without requiring full platform replacement. It is recognised that this is likely to be a longer-term activity due to the costs inherent with upgrades.

The future vision – described by the Chief of the General Staff at the 2024 Land Warfare Conference – for a British Army in the near term that "will sense twice as far, decide in half the time, deliver effects over double the distance with half as many munitions"[7] will be realised in concert with increased electrical power consumption on the battlefield. Contemporary military equipment, down to that carried by the individual soldier, are electronically powered to some extent, while most modern force capabilities depend on the electromagnetic spectrum.[8] At present, battlefield electricity is generated by combustion engines that have inherent disadvantages. To fully leverage the advantages of digitisation, the British Army should develop a comprehensive approach to managing electrical energy on operations. The ability to harness, store and distribute electricity efficiently will not only enhance the effectiveness of emerging technologies but also provide an edge in modern warfare. Electricity should be treated as a commodity akin to our approach to ammunition in an environment where supply is no longer limitless because generation through combustion directly impacts force survivability. Operational planning for electrical power usage should start with the individual, with commanders at all levels considerate of efficient consumption and tactical methods of generation and distribution that include storing, scavenging and sharing.

The electrification of the battlefield is not a theoretical future development but a present reality, with a seam of electrical energy everywhere across Defence. Considered and comprehensive power management will enable the procurement and operation of next generation directed-energy weapons, defensive aid suites and sensor networks, all of which rely on consistent and reliable electrical energy. Effective management will enable the increased lethality and survivability demanded of the modern force. The creation of an 'any sensor, any shooter' network requires ever-growing power resources, therefore adapting the Army's approach to energy should not be optional, it is a necessity for maintaining operational superiority in an evolving threat environment. Doing so doesn't just negate disadvantages – it enables advantage. The first stage in approaching operational energy is changing the mindset of how we manage it.

[6-7]Gen Sir Roly Walker, (2024) RUSI Land Warfare Conference GGS closing address. Transcript available here: army.mod.uk/news/pulling-the-future-into-the-present-rusi-land-warfare-conference-2024

[8]Watling, Jack and Sylvia, Noah (2025) Competitive Electronic Warfare in Modern Land Operations, RUSI, p5.

AUTHOR

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'HOW CAN WE DO DIFFERENT THINGS?'

OUR historical journey in this special edition of the *British Army Review* took us from the invention of gunpowder, to the sudden explosion in the use of drones. Gareth Eason concluded that journey for us by pointing out that no-one, before that conflict erupted, was putting the emphasis on drone use (ubiquity, variety and scale) that we see in the current fight for Ukraine. Certainly, people will rightly argue, drones were being used, and have for a long time been used, before Ukraine. Sure, as people will rightly point out, widely varied drone programmes formed part of the development agendas of armies (and navies and air forces) all over the world. But nowhere, we would argue, was anyone proposing (or, certainly, actioning) a programme that brought into service the full panoply of drones, from the simplest to the most sophisticated, from the strategic to the micro-tactical, at the speed and scale that we have seen pursued by both sides from the strategic depths of that war to the squad fights on the front lines in the Donbas. Circumstance has shown a path to change – not measured thought and laboured capability development design. We now all understand that those who fail to positively, comprehensively and rapidly embrace drone warfare will be on the back foot. Both sides in the current conflict now recognise this, but Ukraine moved more comprehensively first (because it had to in order to survive) and stole a crucially advantageous march, in a contest where every exploitable advantage had to be sought, that bought them temporary battlefield advantage and vital strategic time.

Matthias Strohn has pointed out that the slow evolution of firearms into the 18th century produced not just an intended change of capability and therefore battlefield tactics, but an unanticipated change in the very size, structures and cultures of armies across Europe and then beyond. He has also shown

us that tanks, developed by those thinking their way through the stalemate of trench warfare, were exploited through innovative and unconstrained thinking, by those who had no tanks between the wars, to become the very icons of manoeuvre. Andrew Stewart has shown us, both in the air and at sea, that inventiveness forced by the circumstances of war have offered new wisdom and new capabilities. The nugatory arguments of bomber effect, or crewed verses uncrewed, or strategic resolution through air power alone, are all secondary against the simple statement that none of the above matters unless you, first, have or achieve air superiority. The horror that the splitting of the atom introduced to warfare has also offered a propulsion solution that has contributed to making nuclear war less likely. We have seen that context, not deliberate design, brought what we now call 'operational art' into the campaigning lexicon – implemented to exploit difficult circumstance, not just to deal (under protest and duress) with that circumstance. So, history has shown us that it offers us opportunities within threats, where those who seize the moment find advantage in apparent adversity. In that spirit we concluded this publication with two articles, from Warren Chin and Paul Goodall, that offer some pointers which the thinkers may wish to use as they develop ideas into usable action.

We offer a single example of how a re-think, root and branch, of how we are going about developing and procuring fighting capability may change apparently adverse circumstance into positive advantage. In the British Army's very comprehensive review of future warfare, conducted over the last four or five years, and, for now at least, offering thoughts on what is termed the 'recce strike' approach, real possibilities offer themselves.

"But what if the changes that climate change might eventually force upon us also offered clues as to how we might solve the eternal logistics conundrum? What if the climate-change-driven search for non-carbon-based solutions meant that fighting vehicles within those formations did not need carbon-based fuel delivering to them in order to move? What if they could move using sustainable electric power? What if they did not need combustion-based ammunition, but could deliver lethal effect through laser, or other, energy?"

But the sceptics and critics of this approach regularly return to a worrying theme. In the independently manoeuvring so-called 'Brigade Combat Team snow globes' of self-contained fighting power their very strength comes from their independence of action. These 'snow globes' can manoeuvre in neutral, or even contested, space, negating the need to build and maintain the integrity of old-fashioned, numbers-consuming front lines. But, under such circumstances, the nay-sayers point out (with some justification) the logistics just don't work. How many days of supplies (fuel, ammunition, rations, et al) can these 'snow globes' carry? How will the lines of supply hope to work if the lines are contested? Echoing Omar Bradley, the doubters suggest that amateurs and professionals alike can talk tactics as much as they want, but all of that will remain meaningless as long as the true professionals can't resolve the logistics.

But what if the changes that climate change might eventually force upon us also offered clues as to how we might solve the eternal logistics conundrum? What if the climate-change-driven search for non-carbon-based solutions meant that fighting vehicles within those formations did not need carbon-based fuel delivering to them in order to move? What if they could move using sustainable electric power? What if they did not need combustion-based ammunition, but could deliver lethal effect through laser, or other, energy? Under such circumstances one could reduce, or even remove, the need for fuel and ammunition. Now we'd be getting closer to genuinely independently manoeuvring formations, where only the humans within them needed logistic sustenance. So what, then, if we reduce, or even remove, the humans from the equation?

At the core of our thesis, therefore, lies a simple statement. Climate change is upon us. We will all, in time, have to adapt to address this change – either because new technologies will enable us so to do, or because pressing circumstance (moral, practical or imperative) will force it upon us. Those who get ahead of the inevitable will, equally inevitably, be ahead of those who do not.

This is a moment, surely, when serious thinkers and serious practitioners alike will ask themselves not just 'how can we do things differently?', but, rather more imaginatively, 'how can we do different things?'.

Carpe Momentum...

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