An Air Veteran's Perspective

VR Chaudhari

PART-I: LESSONS FOR AIR POWER: LEARNING FROM PAST AND ONGOING CONFLICTS

After 1,000 days of closely watching the Russia-Ukraine conflict, there are probably half that number of articles analysing the lessons of the operations. Strategists, think-tanks and military leaders look at it from the political, strategic, operational and tactical levels, but no matter which way you look at it, there will always be contrasting views.

Tacticians have dissected the efficacy of kamikaze drones, logisticians have analysed the failure of supply chains to keep the armour rolling, and image analysts have examined the bomb damage. New age tech geeks have looked at the 4th and 5th Gen technologies, particularly those involved in battlefield communications. Journalists have questioned the political motives, alliances and fall-outs. Economists have debated the effectiveness of sanctions and the oil prices.

New age technologies will always remain at the forefront of any commentary on conflicts. The first Gulf War will always

Air Chief Marshal **VR Chaudhari** (Retd) is a former Chief of the Air Staff.

be remembered for the targeting strategies and use of precision weapons along with cruise missiles and stealth platforms. It was indeed the beginning of the "Revolution in Military Affairs" (RMA). But the new technologies of long-range communication and use of the Global Positioning System (GPS) for navigation and precision strikes caught everyone's attention and became a part of the 'must have' procurement plans of all militaries. Simplistic Command and Control (C2) became Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance (C4ISR). The development of newer microchips and enhanced computational power gave rise to the integration of myriad systems, multiplying their individual capabilities.

The North Atlantic Treaty Organisation's (NATO's) intervention in Kosovo (Operation Allied Force) had built on the lessons of the Gulf War and introduced new dimensions of air power application. Air power was used to enforce no-fly zones and strike Serbian military targets without a large-scale ground invasion. The air strikes forced Yugoslav President Slobodan Milošević to withdraw his forces from Kosovo and agree to NATO's terms, ending the conflict without the need for a ground invasion This reflected a growing belief in air power as a primary tool for limited military interventions

The U.S. interventions in Afghanistan (2001-19) and Iraq (2003-11) further evolved the role of air power in modern warfare. With insurgencies being the primary threat in both wars, air power was adapted to provide close air support to the ground forces in counter-insurgency operations. The use of drones and fixed-wing aircraft for precision strikes on high-value targets became crucial. Unmanned Aerial Vehicles (UAVs) like the MQ-1 Predator and MQ-9 Reaper transformed air power by providing persistent surveillance and strike capabilities. Drones became a tool for both Intelligence, Surveillance, Reconnaissance (ISR) and targeted killings, allowing for precision strikes with minimised risk to human pilots.

In both Afghanistan and Iraq, the urban environment presented significant challenges for air power. The need to distinguish combatants from civilians in crowded cities made the air strikes more difficult, emphasising the importance of precision targeting and minimising collateral damage. The accidental bombing of civilian targets during the Kosovo campaign (1999), including the Chinese Embassy in Belgrade, illustrated the political and strategic challenges air forces face in avoiding collateral damage and managing public perception.

The NATO intervention in Libya (2011) provided new insights into the use of air power in regime-change operations without committing significant ground forces. NATO relied heavily on air power to degrade the Libyan military capabilities and support the rebel forces on the ground. This model emphasised using air power to tip the balance in a civil conflict. The Libya conflict showed how air power could be applied in low-intensity campaigns with fewer resources compared to major wars like in Iraq or Afghanistan, reinforcing the idea that air power could have strategic effects even without large-scale military engagement.

The Syrian conflict (2011-24) has been a complex battleground for air power, involving multiple state and non-state actors with competing objectives. Russia's intervention in 2015 demonstrated a different approach to air campaigns, characterised by high-intensity air strikes on rebel-held areas. Russian air power was decisive in tipping the balance in favour of the Assad regime, showing how air power can be used to support friendly ground forces in a civil war. The Syrian conflict also saw the rise of anti-drone and anti-aircraft systems. The proliferation of Man-Portable Air Defence Systems (MANPADS) among the insurgent groups posed a significant threat to low-flying aircraft and drones.

Meanwhile, the U.S. conducted a limited air campaign against the Islamic State in Syria and Iraq under Operation Inherent Resolve. This demonstrated the ability to apply air power selectively against non-state actors while avoiding deeper involvement in the conflict.

In the last two decades, new terms began entering our lexicon. “System of systems” thinking implied synergistic application of improved technologies, ranging from electronic counter-measures, data links, stealth, embedded microprocessors and advanced sensors. Since then, battlefield transparency through near real-time information updates became an integral part of any commander’s operations room. A common operating picture was considered essential for decision-making.

In the years before the Gulf War, American analysts had convinced the generals that forces with the most advanced or best individual systems may not fare well against forces that have better information and greater ability to plan, coordinate and attack accurately. The US and its allies had focussed on not only improving situational awareness, but maintaining information superiority through gaining deep knowledge of the adversaries, the nature of potential threats and the use of advanced sensors. It is essential that this is not confused with mere technological capability to produce a common operating picture. When the ongoing conflicts are seen through this prism, what emerges is the question: did the Russians and Ukrainians have a common operating picture? If so, were there shortfalls in data collection, or data analysis? Was it due to inadequate sensors or lack of Artificial Intelligence (AI)-supported decision-making? Or was it due to lack of training and exposure to high-tech systems of the senior leadership?

While the US and its allies were building up their post-war forces based on the lessons of the Gulf War and the conflicts in Kosovo, Syria, Afghanistan, Libya and Iraq, both Russia and

China began focussing on Anti-Access, Area Denial (A2AD) capabilities, based on their own analysis of these campaigns. In the post-Soviet period, a line of Russian military thinking had increasingly played down the centrality of kinetic violence to war. Non-kinetic forms of influence, particularly information influence, had increasingly been interpreted as a means of war by the Russians. Ideas about a 'new war' had been growing in importance in the Russian military and security circles in the years prior to the conflict. This thinking had been generated by top Russian military officers and it emphasised the effectiveness of non-kinetic measures, long-range precision strikes and limited elite force deployment, whilst downplaying the likelihood of large-scale conventional war. After the break-up of the Soviet Union, armed conflicts erupted in Tajikistan, Moldova and Chechnya. High readiness, small units were deployed to quell the violence and their success strengthened their views on new age conflicts. Russian strategists and senior military officers propagated the importance of information warfare and covert actions and subversion. The limited action in Syria further cemented this line of thinking.

The initial phase of the present conflict saw kinetic action centred around the use of special operations forces, airborne forces and long-range strikes. The scant logistical support provided to the frontline units, along with the tactics of the motorised forces, were evidence of this operational plan. When we analyse the final outcomes of this conflict, we will have to weigh the gains and losses against the intellectual merit of the Russian doctrines.

There have been significant advances in technology, doctrine, and strategy from the early 1990s to the present-day conflicts. Each conflict has added or subtracted a dimension of air power and also provided valuable lessons and shaped modern air power. In many cases, air power has not only altered the course of the wars but has also proven decisive in achieving strategic or tactical victories. From World War II to the Gulf War and the modern conflicts in Kosovo, Libya, and Nagorno-Karabakh, air superiority, precision strikes, and strategic bombing campaigns have been critical in shaping the outcomes of the wars. Advances in technology, including drones and precision-guided munitions, have further solidified the role of air power as a decisive force in contemporary conflicts.

Against this backdrop of contrasting doctrines and strategies, it is essential that we look at the major tactical lessons of the conflicts of the 1990s and see how both sides devised their operational plans. This article will focus primarily on the air power aspects and how these were influenced by past conflicts.

The Gulf War (1990-91) is often considered a turning point in modern air power due to the successful execution of a large-scale air campaign. Some key lessons and developments were the use of Precision-Guided Munitions (PGMs) and the importance of Suppression of Enemy Air Defence (SEAD) operations. The Gulf War was a showcase for the effectiveness of PGMs, such as laser-guided bombs. They significantly increased the accuracy of the air strikes, allowing for targeted destruction with reduced collateral damage. In the ongoing conflict, the Ukrainians could strike some critical targets and even target top Russian leadership through precision air strikes. Ukraine received more than 300 Storm Shadow and Scalp cruise missiles from its European allies and was quick to integrate these on the MiG 29 fighters. Its long-range strike campaign was based on targeting Russian C2 and logistics centres, but these did not have much impact as these strikes never reached the critical level of damage that would disrupt the C2 or logistics systems. The strikes themselves were not effectively synchronised with the ground operations that would have halted the Russian offensive. The next priority of the precision strike campaign was to destroy the Russian Black Sea Fleet and to degrade the defences on the Crimean Peninsula. In the initial analysis it has been seen that the strikes using the Storm Shadow/Scalp in support of the ground operation proved less successful than striking naval targets, where the damage caused was absolute and irreversible.

Militarily, the targets are easy to determine. Destroying Russia's ammunition dumps, or the fuelling and arming points for its attack helicopters, or Russian tactical-operational missile complexes, would have a useful effect in reducing the casualties being suffered by the Ukrainians. But the targets that will yield leverage in negotiations will primarily be economic and industrial. These would be in depth and ideally suited for air force strikes. In this case, the Ukrainians were probably constrained from using NATO supplied weapons for fear of escalating the conflict.

The impact of precision strike was further mitigated by the Russian counter-measures. The munitions that were to deliver these precision effects had been employed for almost a year by the time the offensive began. The Excalibur, for example, was achieving around 70 per cent effectiveness at the beginning of the conflict, but by August 2023, it was hitting the designated point only 6 per cent of the time, a rate lower than non-precision munitions. This was because of exquisite Electronic Warfare (EW) counter-measures fielded by the Russians.[1]

On the other hand, the Russian forces conducted a series of missile and drone strikes of varying sizes, using various combinations of drones, cruise missiles, and ballistic missiles, with the primary targets being the power plants, and energy distribution sites. The Russian missile attacks had a roughly 50 per cent interception rate during the three large-scale Russian missile strikes against the Ukrainian energy infrastructure. The increased effectiveness of Russian strikes, as the days went by, was

1. Jack Watling, Oleksandr V Danylyuk and Nick Reynolds, "Preliminary Lessons from Ukraine's Offensive Operations, 2022–23".

not only a result of the accuracy of the missiles and drones used in the strikes, but also due to their exploitation of the degradation of Ukraine's air defence umbrella. While Ukrainian Air Defence (AD) systems were being bolstered by the redeployment of NATO systems, the Russians made use of the window to conserve their precision munitions and use more of their heavy calibre conventional bombs.

Modern air operations, particularly in contested environments like Syria, faced significant challenges from advanced air defence systems. This led to an increased focus on SEAD and EW. The Russians and Ukrainians had to seek out of the box approaches as conventional SEAD was unlikely to be effective and they needed to think of better alternatives to carry out SEAD. The ground forces were given primary tasks of Destruction of Enemy Air Defence (DEAD) using organic firepower. Drones swarming AD, kamikaze drones for DEAD and for carrying out soft kill, were no longer fictional concepts.

The Gulf War had highlighted the value of real-time intelligence. Platforms like the Airborne Warning and Control System (AWACS) and Joint Surveillance Target Attack Radar System (JSTARS) played a critical role in battlefield awareness and target acquisition. The Russians could find targets that were dispersed over a very large battlespace by increasing the number of sensors networked to their conventional and rocket artillery so that they could receive coordinates directly from the UAVs or artillery locating radars. In addition, loitering munitions, particularly of the Lancet family, were being used in large numbers by Russia.

Drones have occupied a considerable space within the field of defence, especially as reconnaissance assets since the extensive use of the Bayraktar TB2 in the 2020 Nagorno-Karabakh War. That conflict demonstrated the apparent supremacy of drones and the ease with which they can alter a battle. However, the same TB2s were relatively powerless against Russia's layered air defences. Russia used a plethora of drones for reconnaissance and strikes, but the most effective use of drones was for providing targeting up to 120 km behind the front line for the Iskander short-range ballistic missiles.

A major lesson learnt from all the conflicts of this century was that without careful frequency management, forces are liable to engage in widespread fratricide in the Electromagnetic (EM) spectrum, including degrading the efficiency and survivability of own UAVs. The Russian forces were able to update their frequencies every 24 hours, deconflicting UAV orbits. Added to this was their ability to synchronise EW with manoeuvre, particularly with their ground forces. It has been observed that the Russians had delegated the management of EW capabilities including counter-measures, to the battalion level, while the Ukrainians had delegated it to a higher level. Ukraine found that with its UAVs, a rapid refresh rate of both software and radios was necessary to maintain their effectiveness.

Modern software-defined systems require sufficiently large bandwidths to avoid broad-band jamming, and yet need to have enough spectrum available for the range of systems that are being operated by all the Services. Centralised allocation of frequency bands may not be the appropriate solution. Flexibility in the use of the spectrum and adaptability to constantly changing Electronic Intelligence (ELINT) inputs will be the key to success. This is going to become the most important factor in joint planning and needs to take into account the spectrum requirements for civilian usage, mobile communications and the limitations of back-up systems. In order to maintain the technological and qualitative edge, it may be prudent to equip our systems with hardware that can be replaced at the field level. This can be supplemented by providing the ability to reprogramme the radios and data links at unit levels based upon the ELINT inputs.

Analysis of all the elements of air power like helicopter operations, combat support operations, fighter strikes and air transport operations would reveal that in the new age wars, dominance over the space, cyber and EM domains will remain the key to success. The characteristics of air power need to be harnessed using the latest technology and innovative tactics. Flexibility, mobility, concentration of force, shock effect, offensive action, and responsiveness can be harnessed for suitable response options in almost all the scenarios that we may be faced with. Air power has altered the course of several wars throughout the 20th and 21st centuries by providing strategic advantages, tipping the balance in favour of one side, and even ending conflicts.

Atmanirbharta or self-reliance, especially in weapons will remain a key takeaway. While many nations gifted Ukraine a significant proportion of their weapons, even at the cost of depleting their own national stocks, this did not amount to a sufficient volume of the equipment required. In order for any concept of operations to be executed, a certain minimum number of critical enablers/ weapons are required for the planners. A shorter development-integration-deployment cycle has to be created to retain the edge over any adversary.

Drawing an analogy between conflicts or listing out the lessons is never a straightforward exercise. The differences between conflicts will always dwarf the similarities, particularly when historical, geographical and political differences exist. Military leaders should not get trapped in contracted comparisons as they may lead to false expectations. Comparisons and analysis of outcomes can be useful for policy formation when made judiciously. The current war in Ukraine may offer clear tactical and strategic insights while raising important questions about planning, support, and operations.

As they say, learn from others' mistakes, don't insist on making your own.

PART-II: TECHNOLOGY INFUSION INTO THE INDIAN AIR FORCE (IAF)

"We will fight with what we have" is an often-repeated phrase by military leaders trained in service to extract the best from available resources, develop newer tactics, and innovate in the usage of the equipment. Everyone charged with the responsibility of defending the nation understands that no country can afford to discard equipment because the technology is outdated. However, the question arises of how to keep pace with new technologies while still operating large numbers of vintage equipment. By the time one got comfortable with the 386 computers, the market was flooded with the 486 computers and soon with the Pentium computers. Similarly, the military hardware that came with the latest generation of microprocessors soon required updates, consuming large chunks of the revenue budget.

SIGNIFICANCE OF EMERGING TECHNOLOGIES

Today, no article, speech or presentation on the future of the armed forces is complete without mentioning Artificial Intelligence (AI). This term has crept into our lexicon in the last decade, while AI applications have been abundantly used for over a quarter of the century across the world. AI technologies have enabled computers to perform a wide variety of functions, including analysing data, translating texts and even making recommendations.

In addition to AI, other technologies are shaping the future of military operations. For example, advances in robotics are leading to the development of more sophisticated unmanned systems for air, land, and sea operations. Hypersonic weapons, capable of travelling at speeds exceeding Mach 5, require AI systems for precise targeting and manoeuvring. Meanwhile, quantum computing holds the potential to revolutionise encryption and decryption processes, offering unprecedented levels of security and computational power.

Space technologies are also becoming a critical component of military strategy. AI plays a key role in satellite management, space situational awareness, and the development of counter-space capabilities. As the militarisation of space becomes a reality, the integration of AI and advanced technologies will be essential to maintaining a strategic advantage.

This article will focus on the possibilities for the use of AI in different realms of military domains.

AI IMPETUS TO MULTI-DOMAIN OPERATIONS

Most of the computers in use in the armed forces are embedded within a weapon system, aircraft, or ship. The exploitation of AI began with the networking of radars and radio equipment and the setting up of advanced C2 centres. Initially, AI was used for target recognition based on multiple parameters. For example, in an AD system, the computer was 'taught' the correlation of height, and speed, the likely type of aircraft, and the direction of approach to warn the operator about the emerging threat and provide a basic form of decision support.

The rapid advancement of AI and other emerging technologies is reshaping the landscape of military operations and defence strategies worldwide. These technologies promise to enhance efficiency, precision, and decision-making capabilities while introducing new challenges that require careful navigation. As nations strive to maintain the strategic edge, AI and related innovations are becoming integral to modern military operations, impacting everything from logistics to combat scenarios.

If one were to list out the futuristic requirements of AI tools, they would be, in no particular order, as follows:

Psychological analysis of candidates seeking to join the armed forces, either as officers or even as Agniveers, could be carried out based on parameters like eye/retina movements and/or heart rate while facing mental ability tests or interviews. Such AI tools would save long hours spent evaluating candidates and help identify the correct temperaments.

As an aid to training, AI systems can bring about a revolution. From bringing in more realism in simulators to creating self-learning modules, the possibilities are endless.

AI-driven Virtual Reality (VR) and Augmented Reality (AR) systems provide realistic training environments. While the same are being exploited in stand-alone systems, integrating multiple AR/VR based simulators can greatly enhance technical training, especially when the time available for training is limited.

Assessment of flying skills based on analysis of flight data recorders can remove subjectivity in marking and grading pilot skills. Even in basic flying training, the objective should be to move away from 'industrial age' training models with pre-set timetables and instruction plans to one that adapts to each trainee's learning pace.

With the impending introduction of fifth-generation aircraft and systems into the air force, we will need novel training patterns. Today, a young pilot in a standard air superiority fighter doesn't have to think like a mission commander until he acquires the expertise and progresses to become a mission leader. But, in the next generation aircraft, due to their power to be able to 'see' across the visible and the electromagnetic spectrum, every cockpit will have large amounts of data being generated, and every pilot will have to be trained like a mission commander from day one. Pilots in fifth generation aircraft cockpits will be able to direct large formations and make decisions based on the big picture of the battle because they will see things that others cannot, and like edge computing, they will have to process large amounts of data. Normally, it takes years to train somebody to attain that kind of cognitive complexity to be able to do multi-domain order of battle decision-making, but thanks to the available and emerging AI tools, the new generation of aircrew will be able to do it in much shorter periods.

War-gaming and exercise planning during peace-time occupy a lot of mind space of the operational staff at training establishments. Simulations using AI can replicate battlefield scenarios, allowing personnel to train in diverse and adaptive conditions.

One of the biggest challenges in the maintenance of diverse equipment is the timely provisioning of spares. Predictions based on past consumption data and stock holdings often lead to overstocking or shortfalls. AI tools can be effectively used to plan for provisioning and storage of spares with minimal disruptions to the servicing schedules, thereby reducing the downtime of any weapon system or equipment. In addition, AI contributes to the optimisation of logistics and supply chain management. Predictive maintenance powered by AI increases the reliability and longevity of military assets. By predicting maintenance needs, planning efficient routes, and automating resource distribution, AI can ensure that military operations are supported effectively and with minimal delays. These efficiencies can significantly increase the success of missions, particularly in remote or contested areas, through efficient resource management and supply distribution by minimising costs and time in transportation and delivery.

AI is driving significant changes across various military domains, particularly in automation, data analysis, and decision support systems. Autonomous systems such as drones and unmanned vehicles exemplify this transformation. These systems can carry out reconnaissance, surveillance, and even combat missions in hazardous environments, reducing the risk to human personnel. AI's ability to process data in real-time also enhances ISR capabilities by identifying patterns and anomalies that may signal potential threats. AI-powered decision support systems are revolutionising command and control operations. These systems can process vast amounts of data from sensors, satellites, and human inputs to provide actionable intelligence. Predictive analytics allows military leaders to anticipate enemy movements, evaluate tactical options, and simulate potential outcomes. AI-driven systems assist commanders by analysing complex scenarios and providing data-driven recommendations.

Such capabilities not only improve situational awareness but also reduce the time required to make critical decisions, while predictive models help commanders anticipate enemy actions and plan operations.

AI BUILDING COMMUNICATION SHIELD

Electronic Warfare (EW) is a vital domain of warfare, and superiority over it will determine the outcome of any conflict. AI tools and AI-supported EW equipment can jam or spoof enemy communications while protecting friendly systems with little human intervention. Machine learning helps analyse and counter radar or signal threats in electronic warfare scenarios. Collation, analysis and dissemination of ELINT data can be efficiently handled by AI-based systems and can be integrated across the users of the spectrum.

Similarly, ISR, the key element of military planning, requires analysing vast amounts of data from sensors, satellites, and cameras to detect patterns, predict threats, and provide actionable intelligence. AI enhances ISR capabilities by integrating elements such as advanced computer vision that enable real-time identification of objects, personnel, or activities of interest with the EW database.

In the realm of cyber security, AI is proving indispensable. Military systems are prime targets for cyber attacks, and machine learning algorithms help detect and mitigate threats by analysing network activity for irregularities. AI can also automate responses to cyber breaches, ensuring swift and efficient counter-measures.

For Human Resource (HR) management, AI applications can sift through large volumes of appraisal reports to identify the right person for the right job. Career planning based on multiple inputs can be made easier. Predictive analysis of the outcome of any HR policy change helps the leadership to make well-informed, data-driven decisions that would stand the test of legal scrutiny.

Among the factors that motivate personnel to dedicate themselves to the service of the nation, the most important are decent housing and schooling. AI modules can help the administrators determine their availability across the country for better planning of accommodation, maintenance and allotment, especially in a joint Service environment.

ETHICAL DIMENSIONS

Despite the numerous benefits, the integration of AI and new technologies into the military will always raise significant ethical and strategic concerns. One of the most debated issues is the use of autonomous weapon systems capable of lethal action without human intervention. Critics argue that delegating life-and-death decisions to machines poses moral and legal challenges, particularly in ensuring accountability.

Another concern is the reliability and bias of AI systems. Errors in data or algorithmic design could lead to unintended consequences, especially when the security of the nation is involved. Adversaries could also exploit vulnerabilities in AI systems and this will require robust counter-measures and continuous innovation.

The global nature of technological development further complicates matters. As nations compete to develop and deploy these technologies, there will be a need to establish regulatory frameworks and reliable means to mitigate the risks of adversarial AI.

WAY AHEAD

The future of AI and new technologies in the military holds immense promise and profound implications. Human-AI collaboration is expected to be a key focus, ensuring that technological advancements augment rather than replace human decision-making. The development of AI-enabled swarming drones, where large numbers of autonomous systems operate in coordination, and often in conjunction, with manned systems, is likely to redefine battlefield strategies. Similarly, advancements in AI-driven simulations and training tools will prepare military personnel for increasingly complex operational environments. The future lies in planning and procuring open architecture systems that give the users the freedom to add on or plug in newer hardware or change the software without going back to the Original Equipment Manufacturer (OEM). Open architecture in the mission computers of fighter aircraft will give the flexibility to integrate new weapons and EW systems. Similarly, open architecture servers in AD systems will allow the expansion of the AD coverage zone by simply plugging in a new radar or missile system.

CONCLUSION

The IAF has remained abreast of technological developments and has capitalised on the prowess of AI, incorporating it in HR management, meteorological services, maintenance planning and many operational planning tools. The focus should now shift towards setting up joint AI application development centres and combining the capacities of the Defence Research and Development Organisation (DRDO) labs with those of the Services so that common applications are available to all the users simultaneously.

As these technologies continue to evolve, it is imperative for policy-makers and military leaders to address the associated challenges responsibly. By balancing innovation with ethical and practical considerations, we can harness the transformative potential of AI and new technologies to enhance security and stability in an increasingly uncertain world.