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AI ENABLED PLANNING AND EXECUTION OF MULTI DOMAIN OPERATIONS

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Abstract

Artificial Intelligence is an emerging domain which has the potential to fundamentally alter the character of conflict. Militaries who can leverage this technology better than their adversaries will have a decisive edge in combat. Incorporation of AI in military, however, has its pitfalls because of the lacune in AI systems such as hallucinations, opacity, lack of true reasoning and multi-modal intelligence. This paper highlights the current AI capabilities and analyses their utility in military systems. It discusses in detail, de-novo utilization of AI models for planning and conduct of Multi-Domain Operations. Finally, it articulates the key imperatives for AI enablement of the Armed Forces.

Key Words

Multi-Domain Operations, Artificial Intelligence, Decision Making, Operational Planning, Wargaming, Red Teaming, Innovative Disruption, Agentic AI, Military Decision-Making Process

"In the age of artificial intelligence, military supremacy is no longer measured by the weight of our munitions, but by the velocity of our insights."

Google Gemini

Introduction

Present and future conflicts necessitate quick assessment of increasingly complex situations, rapid decision making in conditions of uncertainty & ambiguity, and dealing with adversary's accelerating Observe-Orient-Decide-Act (OODA) loops. While key tenets of planning and executing operations have historically remained unchanged, the methodology of execution has seen transformational changes due to availability of new technologies and advanced equipment.

Artificial Intelligence (AI) is one disruptive technology which has the potential of fundamentally altering the character of war. Hence, it is imperative that this technology is embraced and seamlessly integrated in operational planning and execution. This paper analyses the key imperatives for AI based Operational planning and execution in the Armed Forces.

A Perspective on Multi-Domain Operations (MDO)

Despite the recent buzz with respect to MDO, warfare has always been multi-domain. Taking the example of Mahabharata, the foot soldiers, chariots etc represented the land domain, the archers along with the astras the aerospace domain, Sanjay's divine vision the Electromagnetic Domain and disinformation by spreading the message "Ashwathama hathah, narova kunjarova," manifestation of cognitive warfare. Even if Mahabharata is considered mythology, the mere fact that MDO concept existed in ancient times is significant. Examples of MDO are available throughout history of warfare.

What has however changed in recent times is the rapid technological developments in multiple fields such as nanotechnology, AI, quantum mechanics, blockchain etc which is facilitating more effective execution of MDO. Domains of MDO currently include Terrestrial, Maritime, Aerospace, Electromagnetic, Cyberspace and Information or Cognitive Domains. Considering the politico-military nature of conflicts, Economy and Climate (example, water as a weapon) and Diplomacy could be

considered as separate domains, which need to be dovetailed in our conceptualization of MDO. Biotechnology and Human-Machine Teaming are emerging fields which can be considered as additional domains, given their disruptive effect on warfighting.

Overview: AI Capabilities and Application in Military Operations

AI is an emerging field which has applications in multiple domains. Recent advances in Machine Learning to include Neural Networks and associated hardware upgradations providing enhanced computing capacity, have created avenues for application of AI in military as well.

Employment of AI in the Military Decision-Making Process (MDMP) [1] has the potential of enhancing the efficacy of the decisions taken, thereby facilitating the military commanders in obtaining a distinct edge over the military commanders of our adversaries. It is pertinent to mention that various frameworks for military decision making exist such as Military Decision-Making Process (MDMP), Combined Operational Planning Process (COPP), Joint Military Appreciation Process (JMAP) etc, however, key tenets of all remain the same.

AI can also facilitate automation of complex and labour-intensive tasks, thereby significantly reducing the time required for OODA cycle. This can significantly enhance the tempo of operations.

AI is also revolutionizing data analytics and problem solving. AI has already surpassed Human capabilities in playing strategy games such as Chess and 'Go'. AI models are also performing credibly in reasoning tests and mathematics Olympiads. They are also partially capable of innovation as evidenced from Google Deepmind Alpha Fold which facilitated in creation of a database of over one lakh protein structures (identifying a protein structure in few minutes whereas earlier it took few months to few years to identify one structure).[2] With such capabilities, AI models can significantly supplement military decision making and execution of operations.

Large Language Models (LLMs) have seen considerable improvement post discovery of 'Attention' mechanism in 2017.[3] Recent advances in the field have seen emergence of Agentic AI, i.e. models which can accomplish a specific goal by execution of multiple sub-tasks in a coordinated manner, with limited supervision.

LLMs enable complex querying of data, thereby facilitating faster information retrieval. A commander can query the intelligence database to obtain specific information of the enemy that is required for decision making (For example, 'if I choose Course of Action (COA) 'A', what quantum of enemy reserves may interfere with my operations at places A, B & C and in what time frame?'). They can also generate long outputs without losing coherence (for example Perplexity Sonar Pro has a token window of 2 Lakh tokens (approximately 1.5 Lakh words)). Thus, complex documents such as operations orders / instructions can easily be autonomously produced, once commander's guidance and staff inputs are provided to the system.

AI models have also become adept in analysing visual data. Developments in Convolutional Neural Networks (CNNs) and latest trend of utilizing Vision Transformers (ViT) facilitate very high accuracy in visual recognition and classification. This has immense potential for target detection, identification and tracking through ISR resources. Temporal change detection in infrastructure development can also be analysed easily by coupling CNNs with Long Short-Term Memory (LSTM) Models.

Content creation such as video generation has also seen exponential improvement. Videos generated are hyper realistic and do not suffer from earlier shortcomings such as six fingers of the hand instead of five, events occurring in wrong time sequence, inconsistencies in physical laws such as lighting and shadows etc. AI generated content can be effectively used in cognitive operations by creating deep fakes, at the same time, such use of this technology by the adversaries needs to be effectively countered.

AI models are consistently improving in various benchmarks through Parameter Optimization. Models with lesser parameters are now able to provide performance at par with larger models indicating that training methodology of the models and algorithmic efficiency has the potential of creating efficient models with lesser compute resources and costs. Thus, efficient results can be achieved with considerably less resources.

Current models are not restricted to text input and output only. They can take audio, image, video inputs as well and can provide outputs in diverse forms. This multi-modal capability can facilitate Intelligence Preparation of Battle (IPB) effectively.

Development of Generative Adversarial Networks (GANs) has facilitated generation of synthetic data for analysis as well as refinement of outputs through iterative improvements. The process is similar to military wargaming (between 'Generator' – Blue Team and 'Discriminator' – Red Team). Thus, they are ideally suited for COA analysis and prioritization. The only requirement is to integrate the newly developed Large Concept Model [4] architecture with GANs.

Another important area of AI development is the emergence of Mixture of Experts (MoE) architecture [5] which facilitates complex decision making and collaboration on complex tasks by utilizing sub-models which are experts in their respective fields. On the other hand, AI systems still have inherent flaws, wherein learning of the AI system is dependent on quality of data provided and is largely influenced by the algorithmic biases and errors. Artificial General Intelligence (AGI) has still not adequately evolved and the AI systems lack requisite capacity of independent thinking and 'counter intuitive thinking' where the best course of action does not coincide with the most obvious approach. This is more relevant in the military setting as the adversaries make deliberate attempts to surprise and deceive the opponent by feeding manipulated information and executing dis-information campaign.

While AI models have made considerable progress in reasoning and logic (models were able to achieve silver medal in mathematics Olympiad, are able to solve graduate level questions in various domains with accuracy better than average human beings etc), the models are still probabilistic prediction models and lack reasoning in the truest sense. They do not have Human level multi-modal reasoning and understanding (Figure 1, marked in red oval). Hence, while AI systems may assist in planning and execution of military operations, the act of choosing the final decision remains in the realm of Human Decision Making. Implication is that AI based autonomous systems can be used effectively, where the decision does not have associated risks or second order effects, however, where decisions are high risk / high impact, Human in the Loop decision making will remain the norm. Also, while optimization of current AI model architectures may continue, it is likely to result in diminishing returns. There is a need to evolve completely new architecture to achieve the next leap towards Artificial General Intelligence which can assist in complex reasoning, true innovation and addition of new knowledge which is currently beyond Human comprehension and reach. This is when AI models will excel in Military Decision making.
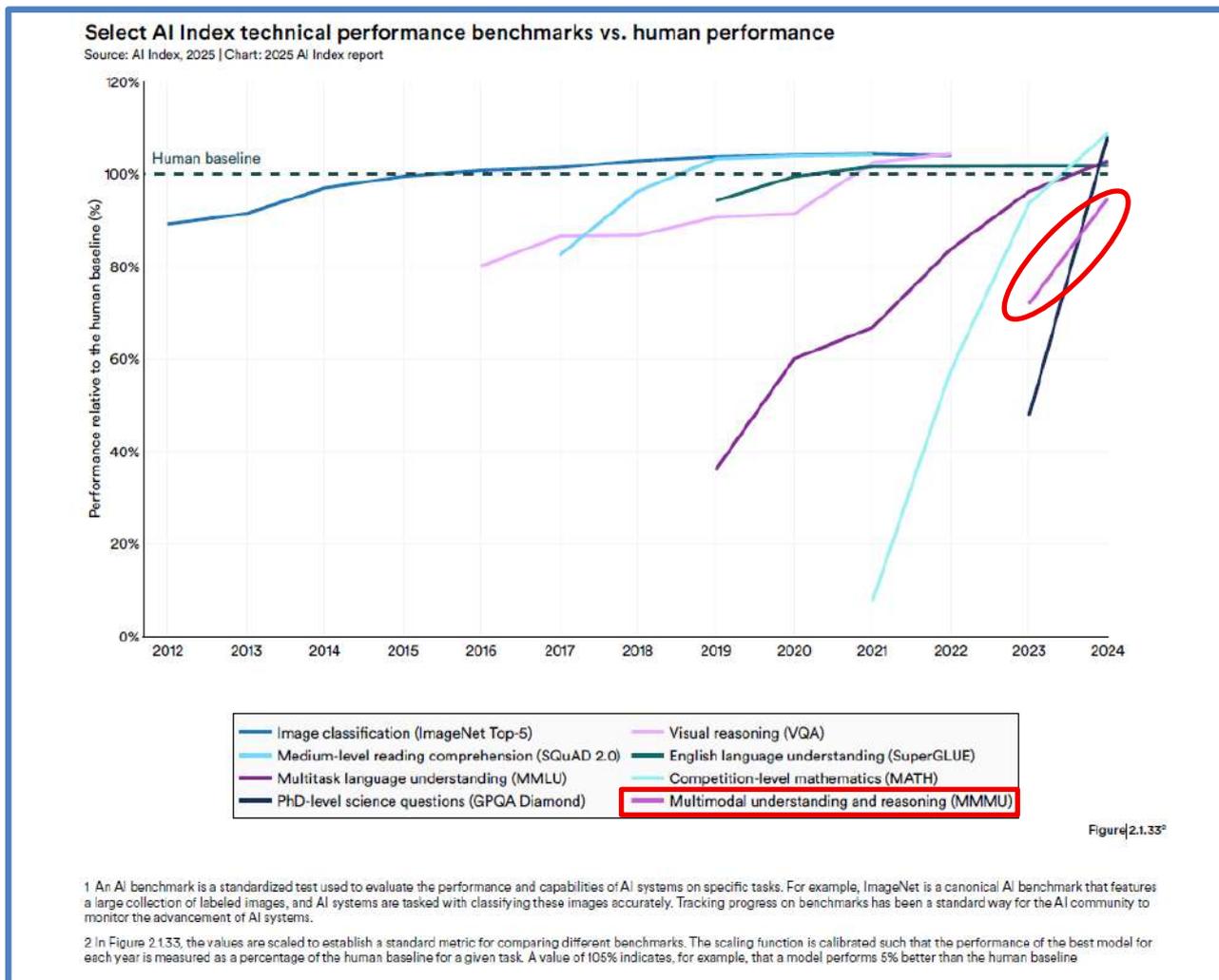
Select AI Index technical performance benchmarks vs. human performance
Source: AI Index, 2025 | Chart: 2025 AI Index report

Legend:
- Image classification (ImageNet Top-5)
- Medium-level reading comprehension (SQuAD 2.0)
- Multitask language understanding (MMLU)
- PhD-level science questions (GPQA Diamond)
- Visual reasoning (VQA)
- English language understanding (SuperGLUE)
- Competition-level mathematics (MATH)
- Multimodal understanding and reasoning (MMMU)

Figure 2.1.33²

1 An AI benchmark is a standardized test used to evaluate the performance and capabilities of AI systems on specific tasks. For example, ImageNet is a canonical AI benchmark that features a large collection of labeled images, and AI systems are tasked with classifying these images accurately. Tracking progress on benchmarks has been a standard way for the AI community to monitor the advancement of AI systems.

2 In Figure 2.1.33, the values are scaled to establish a standard metric for comparing different benchmarks. The scaling function is calibrated such that the performance of the best model for each year is measured as a percentage of the human baseline for a given task. A value of 105% indicates, for example, that a model performs 5% better than the human baseline

Fig 1. AI Index Technical performance Benchmarks vs Human Performance[6] **Source:** Author

Another issue with AI models, is their opacity. While efforts are on to develop AI models giving out their step by step thought process for arriving at the final output, it is seen that there are flaws in the reasoning of AI models. AI models are also prone to Hallucinations i.e. presenting factually incorrect content as true. This can have significant negative impact in the military domain.

Data is the most critical element for effectiveness of AI systems. If the data is biased or inaccurate, even the best AI model in the world would give incorrect output. Key issue for military systems is non-availability of clean empirical data.

These issues bring forth the facet of 'Trust' in AI based systems. If the drawbacks in AI systems result in distrust over them amongst military decision makers, advantages that AI systems accrue will be negated. To summarize, current AI models are capable of providing decisive edge over adversaries if employed diligently, obviating their shortcomings, however, development of better architectures aiming for AGI are imperative for excelling in military applications.

AI in Operational Planning through MDMP Framework

Operational Planning essentially answers the question 'When, Where, with what strength and How should I attack / defend?'. However, answer to this question is not a discrete one-time answer, it is a continuum necessitating, near real time assessment of the situation and decision making. As discussed earlier, the cycle of 'perception' to 'action execution' has been continuously shrinking, making employment of AI indispensable in current and future military decision making. Employment of AI for operational planning to facilitate qualitatively better military operations is discussed in subsequent paragraphs.

Receipt of Mission. A mission received from higher Headquarter (say a mission received at Divisional Headquarter from Corps Headquarter), entails analysing the mission / clarifying the Higher Commander's intent, issuing a Warning Order to subordinate units and formations, and issuing Division Commander's Initial Guidance. The role of AI here would be in facilitating automation, where in the model would analyse and interpret directions of higher Headquarter, prepare draft warning order, disseminate the same post approval, obtain inputs from the Division Commander in an interactive way and issue his initial guidance. The same is feasible with current AI technologies i.e. Large Language Models (LLMs) and Retrieval Augmented Generation (RAG).

Updation of Background Information. Updation of Background Information is a continuous activity which is carried out even during peace time. It entails periodic updation of terrain information in the Area of Interest (AOI), enemy information (deployments, force levels, doctrines, tactics and fighting methodology, training, operational logistics facets, weapons and equipment held etc) and own information. Key issues with respect to this activity are as under: -

- Information is obtained in various forms such as audio (enemy radio interceptions), video (UAV feeds), imagery (satellite imagery), text (hacked documents), Electro-Magnetic (EM) data (Synthetic Aperture Radar Imagery, data from Gun Locating Radars, EM receivers monitoring enemy transmissions across the entire EM spectrum etc). Analysis of this multi-modal data is a time consuming and resource intensive process. Also, collation, cataloguing of data and synthesis of intelligence from the same is a complex and difficult process.

- Terrain inputs are received in a fragmented manner. For example, inputs with respect to a road being constructed by the enemy are received in the form of satellite image snapshots. Such fragmented inputs need to be fused for comprehensive terrain mapping. This activity requires intensive operator training and experience to execute effectively, is time consuming and is prone to human errors.

- Resources to obtain intelligence are always at a premium. If synergy between various intelligence agencies is lacking, there may be duplication of efforts in certain areas at the same time, resulting in informational blind spots in other areas.

  All Armed Forces make an endeavour to conceal information or deceive the adversary through dis-information. Capability is required to identify such endeavours by the adversary and discount them to obtain a realistic battle situation picture.

- As quantum of data increases, searching for specific information becomes difficult. For example, a query like 'What is the quantum of troops that the adversary can concentrate at Place 'A' in a given time 'T' ?' requires querying the database for known enemy peace time dispositions, assessed pre-conflict forward locations, infrastructure available to the adversary to orchestrate mobilization, time required for troops and logistics to move to Place 'A' from various bases, impact of adversary's doctrine/ tactics on the mobilization etc. Such queries, with non-AI based automation are difficult /time consuming to answer.

Employment of AI Systems. AI systems can be employed for enhancing the efficacy of this activity as follows.

- Convolutional Neural Network (CNN) based AI systems can facilitate analysis / classification of images. These systems can be utilized to analyse visual data from various sensors such as satellite imagery, SAR imagery, UAV feeds etc., collate information and synthesize imagery intelligence. These systems can also be used for analyzing video data. Latest trends now include use of transformers (called Vision transformers) in conjunction with CNNs for analysing audio-visual data in a more efficient way.

- Collation of terrain intelligence can be fast tracked with a transformer architecture coupled with CNNs and RAG. Maps, Geographical Information Systems (GIS) can be kept updated based on latest terrain intelligence available.

- AI agents can be employed to automate the intelligence cycle workflow. Current systems also facilitate multiple AI agents with different strengths collaborating together on complex tasks.[7] Use of Agentic AI systems will facilitate better operational efficiency and more judicious employment of scarce ISR resources. AI systems can also advice on the optimal tasking of each asset to maximize the intelligence gained.

- Once background terrain and adversary data is available, transformer based LLMs can facilitate complex querying in natural language, thereby providing required information to the military planners, literally at their beck and call.

Intelligence Preparation of Battlefield (IPB).Maximum advantage of utilizing AI systems can be accrued for this operational activity. IPB [8] is process oriented, however, also requires superlative cognition and intelligence. AI systems can facilitate in areas where human cognition struggles and is sub-optimal.

- **Defining Battlefield Environment**.

  - This process is essentially defining the state space [9] (a mathematical concept that represents all possible configurations or states of a dynamic system at any given time) and narrowing down the input parameters to prevent analytical factors overwhelming the decision process. Therefore, a military commander lays down his AOI and Area of Operations (AOO).

➤ However, in MDO, it is difficult to make such distinction, as the AOI may span the entire geography of the adversary, including the third dimension and may also include non-tangible domains such cyberspace and cognitive domains. Hence, instead of clear-cut delineation of AOI & AOO, the concept of 'Attention' used in AI transformer models is more apt in such a scenario, i.e. more emphasis needs to be given to obtain intelligence regarding factors that have maximum impact on the operations that are being conducted (irrespective of their geographical location). For example, an airbase in a separate theatre may not form part of AOI of a Division Commander, but he has to be cognizant of the air operations that can be launched against his troops from that base. AI models can work out interse importance of various intelligence inputs required and weightages for the same in varied operational settings. These will come in handy while prioritizing employment of ISR assets.

- **Describing the Battlefield Effects**. Key aspect of this step entails evaluating the terrain's effect on military operations.

➤ Based on the background data already available and latest intelligence gathered during hostilities, the Modified Combined Obstacle Overlay (MCOO) can be prepared by AI systems in near real time. AI systems can provide more granularity to this process. Manual system entails marking of unrestricted /restricted / severely restricted areas, which provide limited gradation. AI systems can facilitate quantifying the terrain friction, thereby clearly articulating the effect on mobility and operational tempo, if specific Mobility Corridors / Avenues of Approach are selected. This concept of 'terrain friction' is not limited to physical domain but is equally applicable for MDO. In the context of MDO, the definition of 'terrain' should be considered as 'A medium through which various Lines of Operations are executed'. Let us take an example of executing offensive cyber operations against a well-protected target 'A'. Executing a direct attack may be difficult, but executing an attack through intermediary/intermediaries which are less protected may be easier. Similarly, effect of various 'Key Terrain' i.e. areas whose seizure / control affords marked advantage to either combatant, can be quantified,

which will provide marked benefits during Course of Action (COA) development.

➤ Preparation of various terrain attributes overlays can be automated with an AI System. Thus, combined effect of multiple terrain attributes on military operations can be presented in a more cogent manner. For example, while selecting a route for attack, overlays of vegetation, contours of terrain, built up areas etc can be considered together to identify a route which minimizes exposure to enemy observation and fire.

- **Threat Assessment**. This step in IPB entails creation of Enemy's Doctrinal Templets, description of Enemy's tactics and options and identification of Enemy's capabilities and High Value Targets.

    ➤ While identification of Enemy's capabilities and High Value Targets is a cognitively neutral step (does not induce bias in decision making), creation of enemy's doctrinal templets and description of his tactics may induce biased operational decisions. It may force us to believe that enemy will execute operations within a narrow range of possibilities characterized by his 'Doctrine', whereas an adversary may not restrict himself to a particular doctrine / pattern of operations at all, during hostilities.

    ➤ AI systems can help in mitigating such biases. With High Performance Computing available, there is no need to consider one particular doctrinal templet. All known doctrinal templets can be fed to the system during training. This will facilitate creation of more diverse dataset of possible Enemy CsOA during COA development thereby removing any operational blind spots and reducing chances of being surprised. An apt analogy is that of Chess Engines. Chess Engines do not predict that the opponent will open the game with a Ruy Lopez or Queen's Gambit. All possible chess openings are already available in the database. The chess engine evaluates the position in real time after every move, looking 20/30/40 moves ahead. The same approach is recommended for AI based military decision making.

- **Determine Threat CsOA (Enemy CsOA)**. The last step of IPB is to determine threat CsOA. The IPB postulates that Threat COA models should meet the tests of suitability (in achieving enemy's likely objectives or desired end state), feasibility

(capable of being executed), acceptability (to the enemy considering the risk and expenditure of resource involved), uniqueness (each COA being uniquely different from others) and consistency with enemy doctrine. However, except for the uniqueness aspect, all other characteristics are assessments which can go wrong.

> With AI based operational planning it would be prudent to retain all possible enemy CsOA and catalogue them during peace time. Considering the total resources available to the enemy all possible combinations of force application (including support functions), time & space could be listed to ensure that no threat COA is missed out.

> Once this is achieved, other steps of the IPB i.e. creation of Situation Templets with Named Areas of Interest (NAIs) for each enemy COA, creation of Event Templet based of unique NAIs which will facilitate in identifying COA undertaken by the enemy at an early stage, identification of Decision Points and articulating Decision Support Templet and Target Areas of Interest etc can be done in an automated manner.

- **Assessment of Resources**. Having undertaken the IPB, the next important step in operational planning is assessment of own resources (forces, weapon systems, logistics etc). This activity is also a continuous activity which is ongoing during peacetime as well.

> Since, maintenance of requisite resources has a cost implication, all armies function on Base Level of Preparedness (BLP) i.e. minimum level of preparedness to be maintained at all times with plans for rapid surge if hostilities are imminent. Two important questions with respect to BLP, which military planners need to answer are: -

   o Is the BLP adequate to deter hostilities?

   o Is the BLP adequate to stem enemy surprise offensive and prevent him from achieving his objective before own surge in resources is affected?

> These questions seem to be simple but necessitate complex analytics and simulations. The first question necessitates complex simulations and scenario planning, incorporating Game Theory. The second question

necessitates ascertaining   War Wastage Reserves of various equipment and ammunition in the vast armed forces inventory. It entails analysis of their placement and simulations to ascertain whether the deployment posture is adequate. The surge capability (capability with the industry, Defence PSUs, availability through fast-track procurement from Friendly Foreign Countries etc) also needs to be assessed. In the absence of an AI assisted system, such decisions largely remain subjective and speculative. An AI system can assist in providing quantitative assessments based on empirical data.

➢ To ensure victory in conflict, apart from the quantitative aspects, qualitative aspects also merit attention. In Operations Analysis, Weapon Effectiveness Index (WEI) is used to compare combat power of adversaries, however, the same is compared on weapon-to-weapon basis, i.e. WPI of a tank is compared to WPI of enemy's tank. However, the right way is to compare WPI of own tank with A/tk weapons of the enemy. Another issue with WEI is that it 'averages' the result based on multiple parameters. It does not take into account the non-linear or exponential effect of a few parameters of a weapon system. For example, let us consider two drone systems as below: -

Parameter	**Drone A**	**Drone B**
Range	40 kms	50 kms
Endurance	120 mins	150 mins
Explosive Content	5 Kgs	10 Kgs
Drone Guidance	RF Link with GCS	RF Link with GCS
Operating Frequency	Ku Band with frequency hopping 500 hops / sec	ISM band, 10 pre-fixed frequencies

Terminal Seeker on the Warhead	IR	IR

> Apparently, drone 'B' seems to have a better WEI, however, the fact that it is operating in the ISM band with pre-fixed frequencies has disproportionate negative effects, as it can be easily jammed or spoofed. All other superior specifications of the system get negated due to this one significant, but apparently innocuous drawback. Use of a right jammer will make this superior equipment futile. This leads us to the concept of 'Innovative Disruption' i.e. using simple, lower cost equipment to make superior adversary equipment ineffective by addressing its critical vulnerability. Other examples of Innovative Disruption include use of cardboard kamikaze drones which could not be detected by many EW systems, use of COPE cages on A vehicles against munition dropping drones and use of longer range BVR Air to Air Missiles against 4/5th Generation Fighter aircrafts. While assessing and comparing resources with our adversaries, AI systems can provide insights for Innovative Disruption, which can then be dovetailed in own equipment.

> Another important aspect with respect to military resources is its cost-benefit analysis. Ultimately 'Cost of War' becomes an important politico-military parameter which governs the trajectory of conflicts. In this context, resources planning should be undertaken in manner, wherein combat power is maximized per unit cost of war. This is to say, given that all other things are equal (range, impact on enemy operations, destruction potential etc, a resource should have minimum cost). Currently, these decisions largely remain subjective without any empirical data. With AI models, and utilizing tools such as Monte Carlo Simulations, Analytic Hierarchy Process (AHP) etc such decisions can be taken in a more effective manner. To give an example, should we invest in sixth generation fighter aircraft or manufacture a greater number of UCAVs? More aircraft carriers or more submarines? More 'A' vehicles or more drones? If both are required in each case, what should be the monetary allocation for each in future? While there are no

obvious answers, AI models can assist decision makers in taking such decisions better, given the National Military Objectives and our National Military Strategy.

- **Synchronization of Own Actions**. We discussed in detail initial steps of MDMP and application of AI models therein. Another important activity during conflict scenario is synchronization of own actions.

  - ➤ Once Warning Order is received, it triggers multiple preparatory actions at multiple levels, recouping of weapons and equipment, recall of persons who are out of unit, preparation for mobilization, collection of latest intelligence inputs, seeking detailed orders from higher HQ etc. All these activities occur simultaneously at multiple levels and there is a requirement of synchronizing actions by various stakeholders in time and space. Rapidity of these actions, non-availability of complete information at all levels leads to 'fog of war'. With AI capabilities now available, all such activities can be automated and synchronized through Agentic AI systems, thereby leaving Human Decision Makers to concentrate on more important decisions. These AI systems can be created based on 'Human in the Loop' format, thereby retaining Human oversight and undertaking mid-course corrections, if things go wrong.

  - ➤ Apart from preparatory actions, synchronization is required during conduct of operations as well. The concept of synchronization matrix exists in the armed forces. However, during conduct of MDO, this synchronization becomes extremely complex, wherein limitation of Human cognition can affect the efficacy of operations. AI systems can be effectively employed for fine tuning operations and increasing operational tempo.

- **Courses of Action (COA) Development**. Analysis of COA is a resource intensive activity, which places a restriction on number of CsOA developed. Another aspect to consider is the granularity of COA development. For example, for a Corps Level Operational Plan, is there a need to consider different outcomes of Section Level Battles? As a rule of thumb, two levels down (Brigade level for Corps Level planning) are considered in military planning, however with higher compute, availability of AI based resources and capability of executing faster operational

cycles (intelligence cycle + targeting cycle), we may consider 3-4 levels down. The defining tenet is that the increase in accuracy gained through consideration of more granular CsOA should be advantageous than the tempo lost due to delay in decision making (due to requirement of considering more decision parameters at each time step).

➢ To address the above issues, it may be prudent to undertake this activity during peacetime to genghjfgyrtdtgerate a comprehensive database of all possible own CsOA based on chosen enemy COA at each timestep. A representative example of the concept is given below.

Fig 2. Concept of COA Development **Source:** Author

➢ Going back again to the Chess Engine analogy, a Chess Engine identifies various plausible 1st moves for White, subsequent Black moves to each of the white's 1st move and so on. Current chess engines can evaluate few hundred million nodes per second (224 million nodes per second for Stockfish engine as of Jan 2021) [10]. Chess engines also use various tree pruning algorithms, i.e. lines of play which are disadvantageous are not analysed in depth, whereas promising lines of play are analysed more deliberately for much longer move sequences.

➢ The Chess analogy encapsulates the broad strategy for military COA development. However, it needs to be kept in mind that military operations are much more complex than chess for the following reasons: -

S NO	CHESS	MILITARY OPERATIONS
1.	Each move made by a player is visible to the opponent. The information of the opponent is complete.	Complete information of the adversary is not available. In addition, adversary's efforts at surprise and deception may corrupt available information. Thus, decisions have to be taken in conditions of incomplete / corrupted information.

S NO	CHESS	MILITARY OPERATIONS
2.	Each player takes turns to play. OODA loops are discrete and non-concurrent for each move.	Actions of adversaries are simultaneous. OODA loops at each timestep are overlapping and concurrent.
3.	Evaluation of the board position is mathematical and easy.	Multiple intangible factors have an effect on the operational situation. Thus, evaluation of the same is difficult.
4.	Permissible moves are laid down as part of the rules. The scope for innovation is limited.	Actions by each opponent are not laid down. There is scope for innovative tactics and actions 'which are not part of rule book'. Hence, the number of

		permutations to be evaluated increase exponentially.
5.	Limited scope for cognitive operations.	In chess, you cannot influence your opponent's mind, except with your game play. In military operations, concerted Cognitive Operations can be executed to affect the enemy's cognitive capabilities (perception & decision making). It is feasible to play on the enemy's emotions / biases and make him incorrectly assess the operational situation and choose a COA which is disadvantageous for him.

➢ Considering the above facets, imperatives for AI based COA development are as follows: -

    o COA development should not be limited to initial CsOA. Own COA should include action-reaction-counteraction-counter counter reaction and so forth, at least for initial 10 days of conflict. Who, When, Where, With What, How and Why (AI systems are prone to hallucinations, hence the 'Why' aspect also needs to be included for the model to reason correctly and for military planners to assess whether the Chain of Thought of AI is logical or not) would be the parameters for consideration for enemy COA and own COA at each timestep.

    o Weightages for various factors for evaluation of an operational situation will have to be identified, based on assessments of past battles / wars. These weightages however, would be dynamic, based on the situation. For example, weightage for degradation by enemy artillery would be different if own troops are with / without

Over Head Protection. Similarly, weightage would be different for static / moving targets. Thus, assessment of the situation will entail, complex mathematics involving, matrices, differential equations and Markov Chains. There would also be a requirement of gathering empirical data during our training exercises to adjust the weightages of the AI system, rather than the traditional 'Well fought Red, but Blue is the Winner'. For example, what would be the effect if 100 drones with 10 kgs explosive content swarm a company defended locality simultaneously? – such combat engagements need to be empirically documented.

o Being resource intensive, COA development should be carried out during peacetime and the entire sample space of all possible CsOA should be created using AI systems. Own and enemy actions at each time step need to be documented to ensure that all possible options are considered, including the worst-case scenarios. Once a conflict commences, the progress of operations can be mapped as an evolving Line of Operations (LOO) within the identified COA sample space (Refer Figure 2). It will help in considerably reducing the decision time during conflict and in executing the best COA to achieve the desired end state.

o Current LLMs are essentially predictors, who predict the next word / set of words based on probability distributions. Thus, these models are 'conformist' in nature, whereas a nonconformist approach is required in military planning. Achieving surprise, deceiving the enemy, innovating a new weapon system, using existing weapon system in an innovative way, changing tactics which the enemy does not anticipate etc are pre-requisites for military success which seems beyond the capability of existing AI systems. While Generative Adversarial Networks (GANs) exist, which facilitate wargaming in some form, however, we are still way off from genuine AI based military innovation. Steps will have to be taken in this regard to maintain an edge over our adversaries

- o Tactics to Strategy vs Strategy to Tactics approach towards AI based COA development could be two-pronged. First is incrementally maximizing the operational advantage at each time step, such that it cumulatively adds up to a 'victory' in the end. Thus, maximizing tactical advantages over time, becomes the strategy. The second approach could be to define a strategy, define own LsOO to execute the strategy and assess the impact of enemy's best COA on own LsOO at each time step. The second approach is currently less suited for AI based military decision making, as AI models are still not competent in 'understanding' abstract concepts and ideas. Efforts in this direction have been initiated through Large Concept Models, but there is still a long way for these models to evolve and be used in military decision making.

- **COA Analysis and Comparison**. This step includes the detailed analysis of the CsOA along with assessment of likely enemy actions at each decision node / time step to identify the pros and cons of each COA, identify the likelihood of success, inherent risks and required risk mitigation actions.

  - ➤ The sample space of developed CsOA can be very large. Hence Optimization techniques have to be dovetailed in AI systems, so that it can recommend best available CsOA commensurate to the operational situation, in the requisite time frame. Various optimization techniques are discussed below: -

    - o **Breadth First Search**. This entails analysing the first action-reaction sequence for each COA. It is beneficial in identifying a COA which can give better payoffs in the immediate time frame and can assist in narrowing down options for more detailed assessment. In such a search, where there is lesser payoff for the first node but has much better payoffs in the subsequent nodes may get missed out.

    - o **Military Objectives based Optimization**. COA options space is also shaped by the higher intent. Intention could to maximize gain (capture maximum enemy territory), minimize loss (capture enemy territory, but no loss of own territory acceptable), achieve specific end state with

minimal loss (re-align LOC favourably in a particular sector), destroy the enemy completely without consideration of cost (destroy enemy's strategic reserves to ensure that enemy cannot launch an offensive for next 10 years) etc. Game Theory discusses these scenarios through various criteria like minimax, maximin, minimin etc. There may also be other 'Terms of Reference' stipulated by higher Headquarters, for example, Not to Cross the International Border, Desired End State to be Achieved in Seven Days etc. Such stipulations will shape the available options space.

o **Least Cost COA**.At times the Cost of War may be an important criterion. Cost may be in monetary terms or in terms of lives lost. Minimizing the cost could be a criterion that can be applied for shortlisting CsOA for further analysis.

o **Tree Pruning Techniques**. A number of optimization techniques such as Alpha Beta Pruning, A^* Search, Bi-directional Search, Heuristics based Search etc are available to enable faster searches in the decision trees. These techniques are suitable for narrowing down the search space for various CsOA and following the LsOO that are most beneficial to achieve the objectives.

o **Selecting LOO with Non-Linear Payoffs**. This entails selection of a Decision Tree Branch where score of each adversary is nearly similar for a long streak, but has a depth node which results in an exponential increase in score for us. In essence, it entails selection of a COA where surprise is achieved and a key operation addresses the enemy's Centre of Gravity.

➢ **Red Teaming & Wargaming**.These steps facilitate a 360-degree appreciation of finalized CsOA to identify loopholes in own COA if any and assist in taking actions to mitigate the shortcomings, thereby refining own CsOA. Key imperatives to execute AI based Red Teaming and Wargaming are as follows: -

o As discussed earlier, wargaming is currently restricted to action-reaction-counteraction trio, which with AI needs to be extended to cover many more decision nodes – at least 10 days of conflict.

o Red teaming is a step wherein the most talented officers try to simulate the thinking of the adversary and identify shortcomings of own COA. For Red Teaming, AI system needs to be trained through Supervised Learning, wherein the best available officers, assess the outputs of the AI system and teach the system, where it went wrong.

o Data of past battles / wars should be fed in the system along with outcome of the battles / wars, wherein AI system can draw inferences through unsupervised learning. It needs to understand what constitutes 'good operations.'

o 'Innovative thinking' needs to be ingrained in the system, which is currently a lacuna in AI systems.

o It needs to be ensured that the AI model training results in 'emergence', wherein the model is able to think intuitively for novel operational situations rather than merely templating what it has learnt through training data. An example of emergence is the 37th move by AI engine 'AlphaGo' in second game with Lee Sedol, World Champion of the game of 'Go'. This move had a 1 in 10,000 chance of being used, but was selected by the AI system, despite its low perceived probability of success.[11] This pivotal and creative move helped AlphaGo win the game.

o During current wargaming, qualitative judgements are made regarding whether a particular COA is 'good or bad'. At best, various CsOA are compared to consider interse ranking. However, no system exists to quantify the extent by which one COA is better than other. The valuation part is lacking. In case AI systems are to be incorporated in decision making, such quantification based on empirical data, wherever possible and heuristics will have to be evolved. Precedence for the same exists, for example, chess engines are able to quantify

'positional advantage' of a player in numerical terms, even if the number of pieces of both players on the board are exactly the same.

- o While quantification in wargaming is an essential new inclusion, the qualitative aspects still have their place. This is important for the AI system to bring out lacunae in own COA and suggest risk mitigation measures based on assessed risks. An AI system can highlight to military planners if any important facet has been missed out in decision making and can also suggest innovative measures for contingency planning, to minimize risk in the selected COA. However, these actions are difficult to emulate for regular LLMs. The Red Teaming portion of the AI system will essentially have to be built on Large Concept Model architecture.

➢ COA Analysis has to be carried out under conditions of uncertainty, incomplete information and at times misinformation. AI systems due to their superior computing and data analytics capabilities, are better suited to analyse stochastic and dynamic environments and would provide critical value addition for military decision making. A civilian use case exists in the financial markets. Algorithmic trading using AI tools is being carried out by quant firms. Financial markets are essentially stochastic and have lot of similarities with the military environment (own loses are unacceptable, resources with all participants are finite, it is a zero-sum game, complete information of the operational environment is not available to the participants, participants make attempts to manipulate / deceive the opponents etc). Thus, military AI systems can be refined by drawing lessons from quant AI systems.

➢ Recent development of MoE Architecture in AI is likely to facilitate its employment in military decision making. This architecture is well suited for military planning which require experts in multiple fields such as operations, intelligence (detail knowledge of adversary), logistics, communications etc. MOE AI system can be effectively utilized for COA analysis. Final decisions taken by the military commanders are based on their personality. Some commanders may take bold decisions, some may take risk averse decisions, some would follow military manuals by the letter, some may be

maverick in their approach. To ensure that the final military decision is unbiased and rational, the method of collegiate decision making is resorted to, wherein a military commander discusses plans with his superiors, subordinates and staff before taking the final decision. An MOE AI system can be so trained that its sub-networks have various 'personality profiles'. A collegiate of these sub-system 'experts' will ensure that the decision proposed by the system is more robust and rational.

- ➢ COA analysis and comparison remain a continuous process, based on progress of operations. If COA development has been done diligently, all possible enemy actions would have been catalogued and included in the database. Thus, the task that would remain is to correctly assess the situation, locate the relevant node in the decision tree and ascertain the next best COA. This will significantly shorten the OODA cycle.

- **Orders Production and Dissemination**. When a particular COA is selected, detailed orders have to be disseminated for its execution. This necessitates a common interface at various levels (from unit to Army HQ) and automation in the processes to reduce time. Activities which an AI system can automate are as follows (Considering an example of Division Operational Order): -

  - ➢ Transfer available intelligence picture to lower formations / units, duly collated and marked on a map.

  - ➢ Translate GOC's intent into detailed tasking for lower formations, along with resource allocation. Highlight Terms of Reference if any.

  - ➢ Articulate the execution methodology in detail along with task, time, location, resources. The same can be articulated in text and visual format (marking on a map / generation of a video).

  - ➢ Generate contingencies based on the finalized plan and articulate risk mitigation measures.

  - ➢ Currently, when orders are received from higher HQ, lower formations extract relevant details, prepare their own orders in text and map representation format (which is a time-consuming process) and further disseminate them to lower formations. Similarly, a copy is sent to higher HQ,

which collates the inputs received from lower HQ for the information of the formation commander. With an AI system, this entire workflow can be effectively automated thereby considerably reducing the time and efforts in orders production and dissemination.

AI Application in Execution of MDO

We saw in detail, how an AI system can be employed in operational planning. Now let us consider the application of AI systems in execution of operations. MDO will essentially involve the following types of operations.

- **Cyberspace.**

  - Cyber defensive operations entail defensive measures to keep own communication, and information systems secure from adversarial attacks. AI systems can be employed for continuous monitoring of own systems, intrusion detection, anomaly detection in data traffic, generation of more robust encryption algorithms, cyber forensics and counter espionage.

  - AI systems have considerable potential in conduct of offensive cyber operations. For targeting adversarial networks, extensive base data is required, for example, the cyber defence measures in place, vulnerable points, type of network traffic, electronic signatures of equipment being used, supply chain of the equipment used etc. The most critical system is generally well protected and resilient to direct attacks; hence an indirect approach is necessitated. On the operator front, profiling the operators to understand their motives, emotions, likes / dislikes, impulses, vulnerabilities etc become important. All these aspects require timely, detailed and complex data analytics which can be effectively undertaken by an AI system. AI Systems can also recommend Cyber Lines of Operations, once objective to be achieved is fed to the system.

- **Space.**

  - ISR.Space based Surveillance assets have to be planned diligently due to their high cost. It is important to cover the entire Area of Interest

with minimum revisit time, such that lack of information does not jeopardize operations. This has to be done in a manner to minimize the total cost. AI based systems can be used to undertake simulations to arrive at an optimal mix of space-based assets. An AI system can give out the number of satellites required, their orbits, payloads etc for an optimal space based ISR architecture.

➢ Similar optimization can also be carried out for Position, Navigation and Timing (PNT) and Electronic Warfare (EW) satellites and future anti-satellite systems.

- **Electronic Warfare.** EW includes, Electronic Support Measures (ESM), Electronic Counter Measures (ECM) and Electronic Counter Measures (ECCM). Utilization of AI systems in EW is as follows: -

    ➢ Maximum utility of AI systems in the ESM domain. Adversary emitter activity is noticed at various timelines at multiple locations. Collating these inputs and cataloguing them is a complex activity which strains human cognition. AI systems will be able to undertake this activity easily. The deliverables will be, availability of collated and updated enemy EM ORBAT in real time, querying of data to identify a particular emitter or enemy unit / formation, identification of move patterns of enemy units / formations based on changes in EM ORBAT and identification of enemy EM deception attempts. With LLMs, complex querying can also be resorted to. AI systems can also be used to improve the accuracy of Direction-Finding Equipment by compensating for errors resulting from environmental factors and equipment inaccuracy.

    ➢ Once comprehensive background database of enemy EM activity is available, it will facilitate in execution of effective ECM. Own jammers can be programmed with assistance of an AI System to calibrate, power, direction and frequency band of the jamming signal for optimal effect. This can be done in near real time.

    ➢ Similarly, efficacy of electronic deception can be increased many fold with an AI system. A single command can be generated such as

'Simulate presence of an infantry brigade in the area bounded by coordinates XYZ or simulate presence of a drone swarm of 100 drones in area XYZ at altitude ABC metres. The rest would be done by the AI system connected with requisite EM equipment.

➤ As far as ECCM is concerned, primary role of an AI enabled system would be to identify parameters of the enemy ECM systems and vary / adapt characteristics of own equipment in real time. For example, it can facilitate adaptive waveform design in cognitive radios as against pre-set waveforms in conventional frequency hopping sets. Researchers have also developed Deep Reinforcement Learning based systems that model radar-jamming interactions as Markov decision processes, enabling radars to learn optimal anti-jamming waveform strategies.[12] Thus, AI enabled EW system will be more versatile and adaptive. This adaptive role is crucial in EW, as the cycle of Electronic Attack – ECM -ECCM – modified Electronic Attack continues at a rapid scale with increasingly advanced equipment fielded in each cycle. Employment of AI systems have facilitated in identifying GPS spoofing attacks and reducing their efficacy considerably. AI also enables autonomous ECCM systems that can detect and respond to threats in real-time without human intervention.

- **Cognitive Operations.** A number of synonyms exist for these operations such as psychological operations, information operations, influence operations, Command & Control Warfare etc. the essence however is to degrade enemy's effective decision-making capability while retaining own capability. This end state can be achieved by manipulating information received by the enemy (denying information or changing information), interfering with the mental processes of adversary's military personnel resulting in incorrect interpretation of received information or playing on human emotions / biases to effect sub-optimal decisions despite correctly receiving and interpreting required information. Information manipulation in the EW domain has been discussed earlier. Specific to the cognitive aspects, AI systems can assist in the following manner: -

➤ Real time Data Analytics & Behaviour Profiling. AI enabled systems can pull data from communication intercepts, inputs from intelligence sources, social media activity etc to generate behavioural profiles of adversary's military personnel, especially the decision makers. AI systems can provide insights which are difficult to obtain through Human cognition alone, with respect to their biases, sentiments and emotions. This can assist in influencing their behaviour during conflict.

➤ Similarly, there may be instances, where attitude of larger set of populations may have to be changed which require narrative generation. For narrative generation to be effective, curated messages for each individual / selected groups of individuals based on the target population's cognitive characteristics is necessitated. AI models can assist in generating personalized content which can create the desired impact on each subset of the target population. For example, separate narratives may be required during a conflict for adversary's soldiers, top hierarchy, political hierarchy, common populace of adversarial nation, international media personnel, leadership of friendly foreign nations, leadership of institutions such as UN etc. AI can now generate hyper realistic content in all forms of communication (text, audio, pictorial, video).

➤ At the tactical level, AI enabled content creation can be carried out based on prevailing operational situation to affect the morale and perceptions of troops in selected operational zones. AI is also facilitating deepfakes, which can blur the lines between real and fake communication. This has the potency of not only affecting the target population with fake content, but also of creating distrust with respect to genuine communication.

- **The 'Physical Domain'**

    Terrestrial. Employment of AI systems is as follows: -

    ➤ ISR resources are always at a premium, AI systems can assist in judicious tasking of various resources, so that total intelligence obtained is maximized.

- Data received in various formats (text, audio, imagery, video, electronic signals etc) can be fused to provide a consolidated intelligence picture, in a minimum time frame, with limited human intervention, thereby making near real time situational picture available to military commanders and speeding up the Observe-Orient steps of OODA cycle.

- Hidden patterns in data which are imperceptible to human cognition can be identified. An important use case is detection of enemy deception by combining inputs from Electro Optical sensors and EW sensors.

- Employment in various steps of military planning - the 'Decide' step of OODA cycle has been discussed in detail earlier.

- Mobilization entails a number of simultaneous activities, for example, repair of vehicles, collection of stores and ammunition, sequencing of mobilization columns etc. Efficiency in these can be improved by AI systems employing Queuing Theory. Similarly, other optimization tools can be built in the AI system so that it can output readymade mobilization plan based on inputs by the staff. Graph Neural Networks (GNNs) can be used for the same. Analogy in civil arena is the traffic management system employed in various smart cities.

- Operational Logistics is the most important factor which affects operational flexibility. A commander may desire to change the operational plan based on changed circumstances, but it cannot be executed if not supported logistically. An AI system can facilitate establishing an optimal logistics grid and supply chain, based on operational plan and envisaged future changes, thereby enhancing operational flexibility and minimizing replenishment timings. Such systems are already in vogue in civil arena, notable examples being Amazon, Walmart and even Blinkit and Zomato. Other arenas of logistics where AI finds relevance is predictive fault analysis in equipment, planning and positioning of reserves of various equipment and automated inventory management.

- Communication Planning for operations is a complex activity which necessitates extending optical fibre networks based on progress of operations, establishing wireless Wide Area Networks, ensuring EM Compatibility of various networks operating in the conflict zone etc. An AI system with a Geographical Information System (GIS) module can facilitate in autonomously generating a communication plan once the operational plan is fed into the system.

- Last but not the least, establishing effective Sensor to Shooter Links is an area where AI enabled system can provide disproportionate dividends. It can make this activity autonomous, thereby considerably reducing the time for the 'Act' step of OODA loop. Human-in-the-Loop and manual override functions can assist in enhancing safety and retaining control, without compromising on speed. Specific use cases are as follows: -

    o With intelligence collected over a period of time, strategic targets including their location, layout, protective envelop, vulnerabilities, recuperation mechanism, impact of its destruction on operations etc can remain pre-fed in the system. During operations, the system can suggest strategic targeting recommendations to facilitate quick decision making and can automate targeting with requisite safeguards.

    o While new equipment is expected to be 'AI enabled', requisite modifications to existing equipment by dovetailing AI can increase their efficacy. For example, activity of 'laying' guns and mortars can be automated, requisite corrections based on weather factors and equipment errors can be done autonomously, thereby improving their accuracy and response time. Aiming of weapons such as Rocket Launchers, MMGs, AGL etc can be improved taking into consideration, move trajectory of the target and other engagement parameters. Firing of these systems can also be automated by feeding target data directly from sensors to the weapon system. There is lot of scope for such 'smartization of legacy equipment'.

o The 'Hunter-Killer' concept is emerging as an effective concept for application of aerial weapon systems such as drones, UCAVs etc. With pre-fed instructions, targeting can be made autonomous, thereby reducing reliance on Ground Control Stations, links to which can be jammed. An AI system can also facilitate more 'intelligent' targeting (changing target if primary target is resulting in unacceptable collateral damage, reverting to alternate targets if primary target is a not accessible, working through jamming by utilizing mesh communication rather than point to point communication, steering the 'killer' weapon system through a path which is least susceptible to interference etc). In this context, AI based, autonomous drone swarms are already emerging as a new paradigm of warfighting.

o During high tempo operations, when resources are constrained, an AI system can assist in optimal weapon target matching. Operational philosophy in target engagement has now shifted from a 'Kill Chain' to a 'Kill Web'[13] implying that sensor and weapon systems deployed in the entire operational theatre can coordinate and synergize to engage targets more effectively. This has been possible due to employment of AI based Command & Control Systems. Automating weapon-target matching is increasingly becoming critical as Human in the Loop defence systems are likely to be ineffective in future operational engagements involving autonomous swarms.

Aerospace. Operational Functions such as ISR, operations planning, operational logistics, weapon-target matching, sensor to shooter links etc as discussed with respect to Land Warfare above are equally applicable for air warfare. Few issues which are unique to the air domain are discussed herein.

➢ Battlefield Air Interdiction & Battlefield Air Strike missions are high risk, high tempo, 'one shot' missions. An infantry battalion can attempt another attack on the objective if the first fails, however, an air strike

package cannot re-attempt the strike on the same target – risk is too high. This necessitates careful planning of the aircrafts in the strike package and weapons package carried by each aircraft. This process can be optimized with an AI system, based on the mission objectives.

➢ Fighter aircraft engagements are time critical, delayed decision by even a few deci-seconds (1/10th of a second) can result in the aircraft being hit. This necessitates a system which can autonomously undertake pre-defined functions, say release of chaff / flares, undertaking jamming or initiating an evasive manoeuvre as a counter measure. This has given rise to the concept of an autonomous co-pilot. Notable research projects include, Russian Su-57 Virtual Second Pilot Project[14] and US VENOM (Viper Experimentation and Next-gen Operations Model) based on F-16 aircraft.[15]

Maritime. Unique aspects related to the Maritime domain are as follows: -

➢ Submarines pose a major threat to Naval High Value Assets. Their capability to avoid detection and mount a surprise attack make them more potent. AI systems are now being developed which can increase the chance of detecting enemy submarines.[16]

➢ Threat detection is a problem in naval operations as there is no separation of battlespace and numerous friendly / neutral ships may be present in the AOO. AI systems can be used for faster threat detection through multi-sensor integration coupled with use of deep learning algorithms for anomaly detection (Automatic Identification System spoofing, flag hopping / false flag operations etc).

➢ In maritime operations, multiple naval vessels have to synchronize and coordinate actions. This necessitates a robust system with low latency for coordinating C4ISR in a multi-domain environment. Such a C4ISR system, if AI enabled, will facilitate faster and effective operational cycles. Edge computing also becomes an important consideration for Naval Systems, considering the limited communication bandwidth available to units at sea.

Imperatives for AI Enablement of Armed Forces

While it is evident that incorporation of AI can considerably enhance military operational efficacy, implementation of the same on ground is difficult and nuanced. Critical aspects for effective AI enablement are as follows: -

- **Addressing AI Hallucinations.** AI systems giving out incorrect output with high confidence level is a major issue in current AI systems. Such shortcomings may be disastrous in military operations. To ensure that recommendations of AI system are logical and coherent, explainable AI and 'Chain of Thought' features need to be built into the system. The system should be able to articulate its step-by-step reasoning process and computations for arriving at the output. This will not only facilitate the military decision makers in assessing the efficacy of the output but also assist in enhancing trust in the AI systems. Using the AI systems during peace time in simulation mode and documenting the results can further assist in developing trust in the system.

- **Availability of Clean & Accurate Data.** Non availability of clean, empirical data is a major shortcoming for AI incorporation. For example, if we have to simulate outcome of an engagement of a latest tank squadron and 5th Generation Anti-Tank detachments, no empirical data of such engagements is available. Endeavour must be made to execute mock engagements during training exercises and collect empirical data. In addition, legacy data held in headquarters is in varied formats. This needs to be structured in a uniform schema for meaningful analysis. New data being generated should follow this uniform structure, right from unit to Army HQ / Integrated HQ level.

- **Synergy between Programmers & Military Personnel.** Computer Programmers have limited knowledge of military operations and military personnel have limited knowledge of programming AI models. Hence, close coordination between them is required to ensure that military requirements are correctly dovetailed in an AI system. A project-based approach is recommended wherein the implementation team remains unchanged throughout the development of the project.

- **Approach towards Military AI Development.** An easier and faster approach towards AI implementation is to pick an open-source AI model and calibrate it for our specific military outputs. However, each AI model has a specific 'personality' and cognitive traits, so while it may be tweaked for a different output, it is difficult to change its core cognitive capabilities. The harder, slower but the right way is to develop AI systems for military from scratch including the core LLM / agentic model. Control over the base code and model training methodology will facilitate more granular control over the system as additional capabilities are built into the system.

- **Leveraging Strengths of an AI System.** Commonality of interface and system components pan Armed Forces is essential for executing meaningful MDO. The strength of the AI system is in system integration and automation. For example, it can ensure that appropriate Battle Situation Picture is simultaneously available from Integrated HQ to an infantry battalion. If a common system is used across armed forces, common syntax will ensure seamless transfer of information amongst services. If the same is difficult, at least commonality at all levels within a service (say Army HQ to a Battalion) should be maintained with compatibility between systems of the three services. If different systems are used at various levels, ensuring compatibility between them and making them talk to each other becomes difficult. For example, if the format of operational instructions, orders is different at various levels, or if the GIS frameworks being used are different, it will entail additional repetitive work at each level which is avoidable.

- **Training of AI Systems.** Imperatives for training of military AI systems are as follows: -

  - **Minimizing Training Costs.** Amongst AI models available in the civil domain, there is a race to surpass each other on various benchmarks. Another field for competition is to train the model at minimal cost without losing efficacy. Chinese models made headlines by announcing very low training cost without loss of efficacy. Even if the announced training costs are deflated, the fact that Chinese Models cost much less than US models ($11.2 per input - output cycle per million tokens for Chat GPT 5 vs $ 7.2 per input - output cycle per million tokens for Qwen Max (best

model from Alibaba), as of Nov 2025) allude to the fact that algorithmic efficiency can reduce the training costs considerably.

➢ **AI Model Training Approaches.** Empirical data for various military engagements, both past and present needs to fed to the system to teach it, fundamentals of good military operations. The way military history is taught to the officers, the AI system will have to be taught through supervised learning. In addition, the AI system can be 'present' when operational discussions are on during wargames / operational discussions. The data that this will generate will provide quality inputs for training the model. Another 'R' for supervised learning is the 'Mentor-Mentee System'. All Senior Military Commanders may carry their AI companion, whenever operational discussions are taking place. The AI system can converse, interact, clarify various facets of operational planning from their 'Mentors'. This will help in translating the thought process and 'genius' of Senior Military Commanders into the AI system. This is the best mode of supervised learning as the system will learn from the best, however, associated privacy and security issues will have to be addressed during implementation. Supervised learning however, will not be adequate, as it may make the system compliant and an imitator of training data. There is a need to cultivate maverick and innovative thinking in the system, such that it can generate options, which human military planners may not be capable of generating. Earlier, we discussed the MOE architecture for the AI Systems. It is 'R' that one 'expert' of MOE be trained through supervised learning and another through unsupervised learning. 'Expert' trained through unsupervised or self-supervised learning will be able to provide hidden insights in data and assist in counter-intuitive thinking where required.

➢ **Crowdsourcing AI Training.** Generating data for training and assessing the efficacy of training is resource and time intensive. Hence, civil commercial AI models have utilized a clever ploy – they are providing their models free or with very little cost to the public for a limited period. Thus, users are sharing data with the models willingly and the interactions are studied by the AI models to fine tune

themselves. This approach has to be leveraged for military AI systems as well. Few Lines of Effort are as follows: -

- o Experience available with Ex-servicemen community can be leveraged for training AI models. Their experience regarding how they solved various military problems during their service life would be a good source of training data and the Ex-servicemen community would be willing to share the same.

- o Data of various weapons systems is already available on the internet. Simulation of various weapon engagements can be crowdsourced to obtain verified inputs for the AI system. Similarly, intelligence collection can be crowdsourced to collect maximum information of our adversaries' military / operational capability with top contributors being rewarded suitably. Availability of young, patriotic and computer savvy youth in the country is a significant resource for such crowdsourcing initiatives.

- o Operations can be gamified on the military intranet. Wargaming should be made available on the military intranet with AI system playing the Blue Land (without disclosing the entire array of resources) and opportunity being provided to all officers to play the Red /Yellow Land. With this, intellect of all officers would be available for 'Red Teaming' and the gaming runs would provide valuable data for AI training. It will also bring out the shortcomings of the Blue Land and indicate Lines of Effort to develop Blue Land Capability.

- **Compute.** Large amount of compute is necessary to keep AI systems efficient. This necessitates data centres with cutting edge computing resources. In this context, dual Lines of Effort are recommended i.e. captive data centres with Armed Forces with a mesh architecture to facilitate edge computing and ensure redundancy for critical and confidential data (data that impacts operations directly / data which available to the adversary can provide decisive edge to him in operations) and cloud computing sourced

from private Indian companies / other government agencies for data with lower security classification.

- **Interface with National AI Mission.** Close interface with National AI mission is required for a Whole of Government approach towards AI in defence. For example, the India AI Government website (indiaai.gov.in) does not list Defence as a sector in which employment of AI is envisaged (as of 03 Jan 26, only Healthcare, Agritech, Fintech, Cyber security and Edutech are listed). In fact, defence sector provides a wider canvas for new AI initiatives to be developed and tested.

Conclusion

Current Geo-political situation alludes to the requirement of being prepared for a wider spectrum of conflict. 'Surgical Strikes' post Uri incident, prolonged standoff post Galwan incident, Op Sindoor post Pahalgam incident indicate that the range of plausible operations for which we need to be prepared is vast. The probability of full-scale conventional war may be less, however, when it occurs, combined combat power in all domains will have to be applied to achieve the political and military objectives. Whether a full-scale war or operations short of war, execution of MDO with incorporation of latest technology is an operational imperative. AI is the field which is at an inflection point on the technology adoption curve that can provide maximum dividends in effective execution of MDO and needs to be incorporated in own military operations immediately.

Conceptual framework for implementation of AI in armed forces is largely in place. Effective execution, through Whole of Nation approach by integrating the strengths of the Armed Forces, other Government agencies, Indian IT industry and researchers in Academic Institutions will facilitate integration of AI in Military Systems at requisite pace and scale.

DISCLAIMER

The paper is author's individual scholastic articulation and does not necessarily reflect the views of CENJOWS. The author certifies that the article is original in content, unpublished and it has not been submitted for publication/ web upload elsewhere and that the facts and figures quoted are duly referenced, as needed and are believed to be correct.

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