Emerging Dynamics of Warfare — Role of Artificial Intelligence (AI) and Robotics and how India can exploit it

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"History Honours the Valorous"

Abstract

Contemporary and future full-spectrum warfare would predictably be hybrid in nature, spanning into physical and conceptual dimensions — the former, a swift, intense and short-duration combat against an armed adversary and the latter, a sustained struggle for control and support of the domain of interest. Artificial Intelligence (AI) is fascinating as pursuit of machines to match human decision-making ability, albeit at a higher level of promptness and accuracy — both key components in tactical level of war fighting — hold vital promises for multi-dimensional warfare in fields of command and control, cyberspace, economic aggression, network centric operations, fail proof and predictive analysis of intelligence, deployment of autonomous unmanned platform, autonomous detection-acquisition-classification and engagement of targets, maintenance and upkeep of battle logistics and assets to name a few fields. This paper, while elaborating on conventional AI based force multipliers, also suggests futuristic unexplored application of AI to tilt the balance of power in own favour. The paper concludes with clear and non-utopian recommendation of future roadmaps, containing necessary change management and temporal action plan involving all stakeholders, to

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support India's necessity to remain relevant in changing dynamics of warfare through development and deployment of AI and robotics.

Introduction

What's Past is Prologue. Since time immemorial, victory has always adorned the crown of the most versatile. Ancient examples range from defeat of western crusaders in battle of Hattin (AD 1187) at the hands of the Saracen forces[1], to primordial violence combined with psychological intimidation resulting in occupation of major chunks of Central Asia and China by Ghengis Khan between AD 1201 to 1227[2]. However, with paradigm shift in technological advancement, diversity of contemporary overt and covert warfare has spanned to physical, psychological and cognitive domains.

In view of unbearable cost of victory in prolonged war, contemporary war would be of short duration and high intensity. It will serve a political objective and be fought concurrently in multiple domains. Artificial Intelligence (AI) holds promise to make machines match human decision making ability, albeit with prompter reactions and higher skill level. AI will be integral to fulfilment of each component of Clausewitzian Trinity[3] of warfare; in augmenting conventional combat potential of forces and reducing human casualties while gradually impregnating military systems. This will be tailor made for wartime environment, when multiplicity and multitude of data is extreme, decision periods are short, and effectiveness of decision is absolutely essential. This article focuses on the boundless potential of the AI in emergent war fighting and suggests a future roadmap of relevance.

The Emergent Face of War

Evolving Dynamics of Warfare. The era of large scale conventional inter-state wars is nearing a natural demise, marking the rise of ambiguous, protracted and indecisive conflict in a complex environment. Present conflicts are aimed at deterrence and stabilisation rather than intent to change a regime or defeat a rogue state. Large-scale prolonged conflicts involving the ground invasion of one country by another will be an exception rather than a practice.[4] The focus will be on small wars since the cost of conflict could become intolerable even to the global community in

view of intertwined nature of national and international interests. Following are the major components of contemporary warfare:

- **Hybrid War.** It is characterised by full spectrum wars in the physical and conceptual dimensions in undefined battle space that can be waged from within the territorial boundary of a state, from the rear and the flank.[5] Hybrid conflicts would demand seamless theatrical coordination exploiting Network Centric Warfare (NCW)/ Network Centric Operations.[6]

- **Remote Control War**. Boots on ground and loss of own soldiers and resources in a hostile environment can be limited by employing AI embedded robotics and autonomous systems.

- **No Contact War**. It involves strategies implemented and embedded to effect coercion through desired political, economic, and psychological effects including intimidation, subversion, and destabilisation of key points and neutralisation of command structure in a politico-military-economic system.

- **Outsourced War.** Outsourced combat personnel hired through private security agencies in 'train, assist, enable and abandon' model are major components of overt and covert wars.

- **War of Collusion**. This includes sponsored creation of unrest and armed conflict in the enemy land through citizens of the enemy side.

- **Cyberspace Warfare.** This comprises disruptive use of electronics and computers-based means, for accessing, controlling and disabling of opponent's economic focus areas, command and control networks, research facilities, civilian assets, and military facilities.

- **Information Warfare**. Perception management through propaganda, social media representation and psychological operations are proven and potent weapons to incite proxy war, insurgency and discontent hailing from anti-incumbency.

Modern Warfare – Redefined Arsenal

In modern warfare, superiority will be achieved with following abilities:

- Military strength complemented by a strong economy, immense industrial capacity and deeper diplomatic outreach.

- Ability for collection and accurate processing of multisensory diverse data to facilitate threat perception and decision making under dynamic multiple threat environments.

- Synthesis of mission specific intelligence regarding strength and weaknesses of enemy and subsequent rapid response mechanism and prediction of future course of action by the enemy.

- Reduction in human casualties by use of unmanned systems including localized swarms for accurate reconnaissance, precision targeting and strike and post-strike damage assessments for assured destruction/ effects — at minimum cost.

- Dominance in information and cyber warfare, perception management, psychological operations and economic warfare.

- Automated maintenance/repair to reduce downtime of equipment,.

- Maintenance of optimum operational logistics.

Relevance of AI and Robotics – The Ambidextrous Warriors

Concepts. The following concepts merit attention:-

- **AI.** AI algorithms can emulate behaviours associated with human intelligence like planning, learning, reasoning, problem solving, perception, motion, and manipulation and, to a lesser extent, social intelligence and creativity.[7] AI possesses potential to outweigh human efficiency in big data analytics, pattern recognition, evaluation, prediction, and automation. It would improve economy of efforts by automation of time-consuming tasks and render accurately interpolated interpretation of available data in thousands of simultaneous

dimensions vis-à-vis dimension limited analysis by human minds.

- **Machine Learning (ML)**. ML is an application of AI wherein machines are given access to data and are allowed to analyse and act upon them based on an embedded algorithm in supervised/unsupervised/reinforced way. Through ML, AI systems get progressively better even at tasks that it is not specifically programmed to undertake. Figure 1 below demonstrates major subsets of AI. Based on capability and characteristics, classification of all real and hypothetical AI systems is represented by Figure 2.

- **Robotics.** A Robot is "A powered machine capable of executing a set of actions by direct human control, computerised control, or a combination of both. At a minimum, it is comprised of a platform, software, and a power source".[8] Unmanned robotic systems owe their decision making abilities to AI and ML.

'The peacetime military application of AI would encompass NCW, intelligence, realistic simulations and war gaming, maintenance and inventory management, cyber security and data processing. The additional applications during conflicts would encompass Command, Control, Communication, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR), cyber warfare and intensification of conventional capabilities.

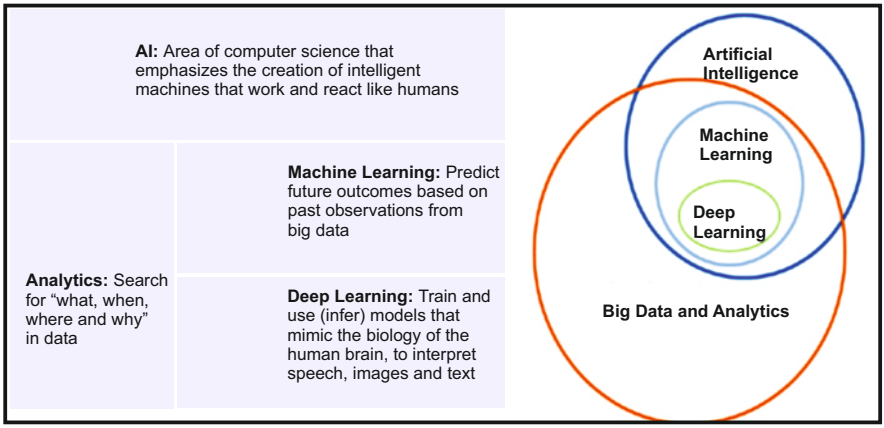

Figure 1 : Graphical Representation of AI, ML and DL as Subsets[9]

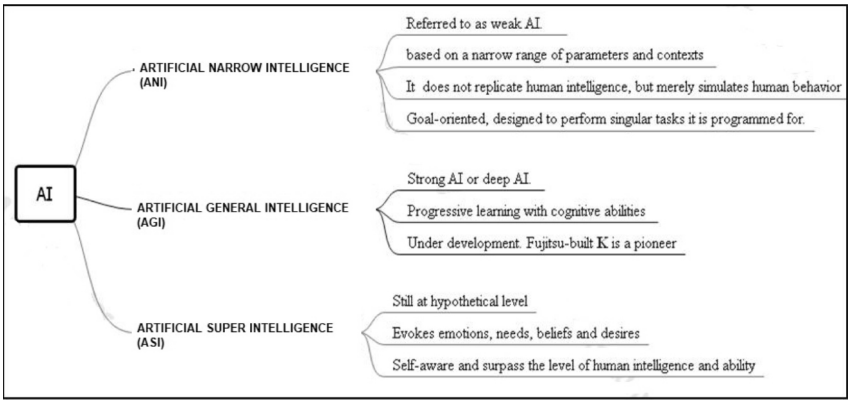

Figure 2 : Types and Characteristics of AI capabilities[10]

Analysis of Battlefield Applicability of AI and Robotics: Conventional Applications. These are as explained below:

- **Network Centric Operations**. It is manifested by intra and inter platform networking of sensors, communication systems, Decision Support System (DSS) and weapons and creation of a single source of information or "Common Operating Picture"[11] for truly integrated multidimensional battle groups. Introduction of ML algorithm in available Combat Management Systems (CMS) would result in effective threat evaluation by identifying an entity as potentially hostile and, thereafter, allocation of priority and resource against it, based upon interpreted level of threat. It will flatten the command and control hierarchy, enhance precision and reduce latency.

- **Unmanned Operations.** With applicability in land/air/surface/sub-surface domains, narrow AI based unmanned vehicles (UVs) in autonomous/supervised modes can be used for varied functions like surveillance, detection, classification, protection of own forces, sacrificial missions, precise targeted killing, explosive neutralisation and dirty jobs, while minimising cost and human casualty. In naval scenario, deployments of underwater UVs equipped with SONARs along with conventional surface groups can enhance sub-surface surveillance horizon and assure protected passage. Monitoring and recording of signatures of all ships/submarines transiting various choke points or contentious grounds by suitably

deployed UVs can serve as training data for AI/ML based detection/engagement systems.

- **Autonomous Weapons**. Human-supervised autonomous weapon systems are designed to allow human operators to override operation of the weapon system, but can select and engage targets without further human input after activation.[12] However, Lethal Autonomous Weapon Systems (LAWS), though legally controversial, can undertake the above operations without human supervision.

- **Loitering Munitions.** Narrow AI based, man-in-the loop, loitering munitions can be deployed around designated area to seek, recognise and destroy intended targets with a reaction time better than traditional means (e.g. IAI Harop). It can be very effective in immobilising tanks, electronic warfare (EW) platforms, thus, halting enemy advance.

- **Mine Countermeasures and Deployment.** Robotic Autonomous Systems (RAS) are best suited for detection, identification, localisation and neutralisation of mines. Post recognition of the mine type, it can be destroyed either by placing a charge on it or by simulating suitable acoustic and magnetic signature for detonating the mines.[13] Furthermore, signature specific cognitive mines can be developed for precise denial of passage.

- **Unmanned borders**. Automated systems with data harvested from multiple sensors like Battle Field Surveillance Radar, motion sensor, IR sensor, hyper spectral imaging and gravity gradiometer with/without interfaced weapon systems can monitor India's vast borders at sensitive and inaccessible locations as tireless omnipresent sentry with minimal human involvement.

- **Cyber Warfare.** It is mooted that relying on human intelligence alone in cyberspace is a losing strategy. AI-enabled tools can be trained to detect anomalies in broader patterns of network activity, thus, presenting both defensive and offensive capability in more comprehensive and dynamic manner. The damages caused by cyber-attacks can range from disabling economic and industrial power points to mislead/ neutralise military systems, including propaganda and 'deep

fakes'[14]. The extreme financial losses imposed by such attacks can force the enemy into submission without bloodshed. Taking over control of networked military hardware/ weapons, masquerading, deliberate insertion of error in positioning data can severely deter tactical ability of opponents in the fog of war.

- **Improved Sustainability of Forces.** Use of drones to render urgent logistic support to own troops engaged in action in inaccessible areas can reduce casualties and increase sustenance. Powered exoskeletons with brain wave reading ability and suitable light weight and high capacity power sources, will enhance mobility and agility of infantrymen while preventing injury.

- **Swarming Drones.** Use of AI embedded autonomous swarming drones with cloud intelligence for cooperatively collective data processing appears to be the future of detection, data relaying, weapon delivery and defensive systems at lesser cost in the long run. These are most suitable for under water operations, where communication with a central control station is the biggest challenge, and in accompanying manned aerial missions as 'Loyal Wingman'[15].

- **Logistics Management.** Pattern analysis based forecast for resource management, including optimisation and automated initiation of relevant spare procurement, will ensure optimal level of inventory sans exorbitant carrying cost.

Breaking the Stereotype: Proposed Applications. These are elucidated in the following paragraphs:-

- **Lambs to Lions – Metamorphosis.** Limitation in the strike range of existing weapon systems are best bridged by weapon carrying Indian Navy (IN) ships in view of existing limited deep strike capacity of IAF assets. AI based systems can pioneer preparation of virtual structural modification plan to convert requisitioned civil shipping of Indian origin for contingency measures in case of loss of warships. Retrofitting of modular missile silos interfaced to semi-autonomous release system and data-linked with sensor carrying military platforms would increase reach and quantum of firepower of battle groups with reduced need for operational turn around.

- **Signature Management**. In ship designing stage, fusing structural drawing, stability criteria and individual vibration signature of machineries, ML based interpolation can recommend positioning and mounting of machineries to minimise acoustic signature. Further, modelling of machinery regimes to mimic merchant shipping or platforms of lower strategic importance can be undertaken to deceive signature specific mines/torpedoes/ loitering munitions during conflicts. Suitable ML module impregnated into Integrated Platform Management System (IPMS) can shift to such regimes in an autonomous way based on assessment of threat levels.

- **Forecasting Enemy Course of Action (CoA).** Predictive analytics by machines can forecast the enemy future CoA based on data inputs like statistical traits of enemy, availability and mobilisation of war assets, terrain/battlefield dynamics and prevalent diplomatic/economic/ political scenario. The same can assist in significantly time compressing the war room sessions.

- **Tactical Decision Assist**. Victory in battle is largely achieved through tactical moves by the commanders based on perceptions, experiences and procedures. ML embedded Decision Support Systems (DSS) with training data comprising of force level, statistics of past decisions and situational intelligence can assist in efficient Multi Criteria Decision Making (MCDM). Such systems can supplement human competence, reduce reaction time and can be designed to suggest pseudorandom yet effective maneuvers to achieve element of surprise.

- **Navigation at Sea**. Using deep learning AI algorithms, the data from multiple sensors of the bridge like Global Positioning System (GPS), Automatic Identification System (AIS), radars, cameras, weather systems etc. can be evaluated to provide actions/alerts to avoid navigational hazards, thereby, ensuring safe navigation of ships at sea.

- **Battlefield Awareness**. AI based fusion and analysis of multi-layered terrain map along with weather condition, imagery, soil structure and enemy position can suggest

composition of strike forces and positioning of artillery, requirement of air support etc. for superior mobility and maximum effectiveness.

- **Data Acquisition and Fusion**. Neural network enabled prediction of acoustic signature of enemy ships/submarines can be undertaken by interpolating open sourced structural data fused with generic information of equipment fitted onboard such assets. The same can be used as training data for embedded ML to recognise the enemy.

- **Prescriptive Maintenance**. Predictive maintenance of machineries and equipment by collation of embedded sensor data by predictive algorithm can minimise breakdowns and unnecessary periodic routines. The same is presently used in F-35's Autonomic Logistics Information System by USAF.[16] ML based systems can combine equipment parameters, documentation and repair history to recommend repair methods by maintainers with average skills in minimal time.

Issues Ailing Progress in Field of AI and Robotics

Absence of Enabling Data Ecosystems. Miniscule access to actionable data, robust data network, reliable repository and lack of formal regulations for anonymity of data has caused negative catalysis in India. Further, limited availability of resident subject experts, low industrial participation, prohibitive cost of imported technology and, finally, lukewarm response by universities, governments and stakeholders, until 2016, have all been proved detrimental.

Despite competence in design and implementation of cutting edge technology, contribution of Indian IT companies like TCS, Wipro and Infosys in development of AI/ML in India has been insignificant in view of negligible automation incorporated in Indian industries. Ironically, from 2001 to 2016, only 14% of all research publications on AI/ML have come from industry, with universities contributing to 86%.[17] Objective to develop military AI systems, singularly and dedicatedly, through Defence Research and Development Organisation (DRDO) has served us no good, whereas involving industry and discrimination at later stage between civil and military specific implementations would have been the right way.

Recommended Way Ahead

Short Term Roadmap (3-5 Yrs). The proposed short term roadmap is aimed at bridging capability and resource gaps, and preparation of framework for development in following ways:

- Identification of mission specific military systems meriting focus of AI investments is the starting point. Armed forces must issue Problem Statement Documents to industry, Public Sector Undertakings (PSUs) and academia and review the proposals for selection of potential technology developers. Shortlisted organisations are to be tasked accordingly.

- Limited import, deployment and study of AI embedded military systems would enrich understanding of design philosophy and algorithms, paving way for indigenous development.

- India needs access to better data and human talent for managing and processing it. The Indian government needs to source data through Indian data handling organisations, and collaboration with international allies. Further, practice of transparency over data and its investments in civilian AI research would enable monitoring and auditing of civilian AI research, assessment of priorities, and identification of new initiatives.

- Funding in fields of AI and robotics in defence sector around the world is far outmatched by that in the commercial/ industrial sector. Progress in relevant field in isolation is not feasible. Implementation of AI alone stands to effect growth of $ 1 trillion in Indian economy. Figure 3 refers[18]. Collective discussion with the industry would ensure higher participation and funding by industry. Development of relevant technology and expertise are to be aimed at applicability in industry and military alike, with joint funding. Once optimal expertise and capabilities are reached, defence specific modules may be designed and augmented through DRDO/ Centre for Artificial Intelligence and Robotics (CAIR)/ Aeronautical Development Establishment (ADE), PSUs, Weapons and Electronics Systems Engineering Establishment (WESEE) and selected industries under non-disclosure clause.

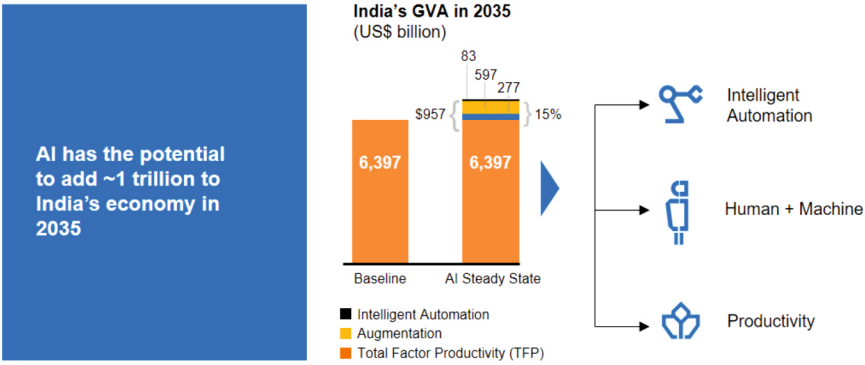

Figure 3 : Potential of AI towards Growth in Indian Economy

- In addition to existing apex body, Defence Artificial Intelligence Council (DAIC), Innovations for Defence Excellence (IDEX) was formed as a 'not for profit' company [as per Section 8 of the Companies Act 2013, by the two founder members – Hindustan Aeronautics Limited (HAL) and Bharat Electronics Limited (BEL)] to work with AI incubators, designated Centre of Research Excellence (CORE) and International Centres of Transformational AI (ICTAI). IDEX must track upcoming start-ups/Micro, Small, and Medium Enterprises (MSMEs) and innovators while opportunistically investing in the promising ones including offering joint Intellectual Property Rights (IPR).

- Dedicated standing panel for AI shall be formed with members from armed forces, academia, PSU, industry and DRDO. The organisation shall be tasked with organising and monitoring of AI and robotics challenges, hackathons across entire country in open category to build awareness, generate interest and shortlist promising technologies. The empowered panel shall facilitate scaling-up, indigenisation and integration of shortlisted ideas and manpower in manufacturing facilities for successfully piloted technologies. The analogy would stand true to major global AI/ML firms which draw talent directly from universities and start-ups.

- To improve information symmetry, collaboration between stakeholders, boost data mining and sharing and to encourage the development of sustainable AI/ML solutions at optimum price and laid timelines, there exist a need to establish a

dedicated directorate at Integrated HQs MoD and command levels with additional manpower sanction. The proposal is in consonance with Niti Aayog recommendations[19] for integrated operations.

Medium Term Roadmap (6-10 Yrs). The proposed medium term roadmap is aimed at implementation of indigenously developed narrow AI/ML technology in defence and fielding of first set of products for following applications while beginning the prototype testing for autonomous systems:

- **Gradual Impregnation of Narrow AI.** Increased impregnation of narrow AI in defence applications (for surveillance, classification, DSS, recognition, maintenance support, mine countermeasures etc.) are to be monitored through dedicated wing of central coordinating bodies like DAIC and IDEX[20] with participation from academia and industry. The organisation should be free of non-specialist civil servants and must be headed and run with achievers of relevant field including defence services. The reporting channel should be short, to prevent India's notorious procedural delay and bureaucratic intervention. Available indigenous robotic UV technology (e.g. Daksh, Muntra by DRDO, Adamya by L & T) is to be integrated with AI capabilities through IT majors and defence start-ups through funded projects. Indigenous integration of battlefield/maritime sensors with existing CMS systems is to be undertaken to prevent disclosure of equipment data to external agencies.

- **Control on DRDO Budget and Delivery Schedule.** Performance of DRDO in field of AI has been less than enthusiastic. The budgeting of DRDO is independent of intervention by armed forces and the buyer is mostly left with compulsion to buy substandard products delivered after excessive delay. Political intervention in involving armed forces towards allocation of Technical Development Fund (TDF) to DRDO and setting project timelines shall be considered.

- **Expanding Collaboration.** Expansion of collaboration with world leaders in AI for exchange of respective strengths and bridging of respective constraints will aid the cause. Wide introduction of AI/ML specific technical courses in IITs, NITs and Centres of Educational Excellence should be implemented

for significantly increasing AI trained manpower. India with cheap technical workforce, second largest Science, Technology, Engineering, and Mathematics graduates (after China), can contribute in reducing cost overheads in exchange for access to research facility, credible data and guided expertise building. The time seems ripe for focused diplomatic efforts to enter collaboration with established state players like USA and Japan in backdrop of anti-Chinese sentiments due to COVID-19 and Chinese misadventures in IOR.

- **Funded Research.** Despite significant progress in IT sector, the nascent level in subfield of AI Research in India by industry can be attributed to lack of research funding and uncertain buyer base. Collaboration with Venture Capitals is especially important as the private sector will continue to remain the leaders in pursuing this niche technology. Dedicated funding for start-ups, MSMEs and academic institutions with clear statement of requirement and well defined timelines is the need of the hour. The funding can be conditional wherein non-performance within agreed timelines would attract heavy liquidity damages. Additionally, research facilities of DRDO/ CAIR and reference equipment of tri Services are to be made available for testing and field trials of products at all stages. Obsession of defence services with completed products on no-cost, no-commitment (NC-NC) basis is to be discarded to support indigenous development.

- **In House Expertise Building**. Infrastructure building, staffing and subsequent inclusion of B Tech / M Tech courses in AI /ML at premier defence institutes like Indian Naval Academy (INA), National Defence Academy (NDA), Military College of Electronics and Mechanical Engineering (MCEME), Military College of Telecommunication Engineering (MCTE) and Air Force Technical College (AFTC) would develop dedicated in house expertise amongst primary users.

- **Departure from User/ Buyer Approach**. With available talent pool, armed forces must graduate from role of buyer/ user to active stakeholder in technology development. Deputation of suitable young officers/men to research labs without harm to their military career can turn up object oriented

progress. Stagnated officers with relevant area expertise may be deputed with research and application labs for prolonged duration or as lateral entry for best exploitation of their expertise.

Long Term Roadmap (11-15 Yrs). Maturing of AI capability for Multi-Criteria Decision-Making (MCDM), cloud intelligence, data collecting and processing ability would follow if short and medium term goals are met on time. India will need to be strategic in its own efforts to integrate AI applications in its weapons systems. Significant indigenous technological progress by 2030 will pave way for alliance with worthy international partners on equal terms and lead to faster development, implementation and, most importantly, regular update in technology.

Conclusion

The Balance of power since world wars has always tilted in favour of nations with superior economic, military, industrial and technical leverage. The future application of AI and robotics for national security must encompass duality of effecting economic growth to support development of military technology and strong military muscle to protect national economic interests. Government think tanks, Niti Ayog, DAIC and IDEX must synergise building of robust ecosystem in following manners:

- Adopt AI in conventional industry by creating a sense of urgency. Accelerate augmentation of industrial production capacity using AI and robotics.
- Build credible source and repository of data. Import AI solutions for immediate kick start of projects.
- Plan and create a Moon-Shot event to draw worldwide attention and project future potential of AI in India.
- Identifying, recruiting and incentivising AI specialists of Indian origin, from international subject leaders in AI, for mentoring projects in India.
- Involved agencies shall be empowered to make decisions and maintain pace. The same would help iterative reorientation of the projects and resources in right direction.

Finally, recent launching of Naval Innovation and Indigenisation Organisation (NIIO) by Honourable Raksha Mantri on 13 August 2020 for end user to interact with fostering innovations, is in the right direction. The organisation, with Naval Technology Acceleration Council (N-TAC) and Technology Development Acceleration Council (TDAC), will hopefully contribute to the cause for the Indian Navy. This is essential to be emulated by the army and air force within provisions of Draft Defence Acquisition Policy (DAP 20). However, the good intents would bear fruit only if practiced in a time bound manner rather than fading with time. It is strongly opined that creation of an independent Ministry of Defence Procurement (MoDP) should be considered to bring in higher efficiency than the present under growths of MoD. Till such time, insistent resonance between existing organisations for development and implementation of AI and robotics towards concurrent growth of military capabilities and economic progress would achieve favourable balance of power[21] for India in the prevailing amalgamated world of constructive, defensive and offensive realism.

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