

**HEADQUARTERS
INTEGRATED DEFENCE STAFF**



**PRIMER ON
ARTIFICIAL INTELLIGENCE
FOR ARMED FORCES**



**Headquarters
Integrated Defence Staff
(Directorate of Doctrine)
Ministry of Defence**



**PRIMER ON
ARTIFICIAL INTELLIGENCE
FOR ARMED FORCES**



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“New and emerging technologies like Artificial Intelligence and Robotics will perhaps be the most important determinants of defensive and offensive capabilities for any defence force in the future. India with it’s leadership in Information Technology domain would strive to use this technology tilt to it’s advantage.”

- Shri Narendra Modi
Hon’ble Prime Minister of India
during DEFEXPO – 2018
In Chennai



वाइस एडमिरल आर हरी कुमार
ए वी एस एम, वी एस एम
कार्मिक समिति प्रमुख अध्यक्ष के
मुख्यालय एकीकृत रक्षा स्टाफ प्रमुख
Vice Admiral R Hari Kumar
AVSM, VSM
Chief of HQ Integrated Defence
Staff to the Chairman Chiefs of
Staff Committee



मुख्यालय एकीकृत रक्षा स्टाफ
२५६ बी, साउथ ब्लॉक
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FOREWORD

1. Of all the modern technologies seen thus far in the 21st century, Artificial Intelligence (AI) has rapidly become the most significant, with potential to revolutionise warfare. AI is a potent enabler with endless applications in both the management of Armed Forces as well the conduct of war.



2. Whilst physical harm to personnel and infrastructure of opposing forces would continue to remain foremost during conflicts amongst nations, the nature of modern warfare itself is metamorphosing by incorporation of non-kinetic warfare involving Space and Cyber domains. Future conflict would invariably be information and data intensive where the Observe, Orient, Decide and Act (ODDA) loop would have significantly shrunk. Swarms of intelligent machines may prove more effective at delivering violence at greater volume and intensity. Large number of small, inexpensive, expendable and autonomous systems may join the battlespace. Some of our potential adversaries have already invested heavily in AI. We therefore have a pressing requirement to prepare our Armed Forces for fighting in an AI dominant environment.

3. At the Apex level, Defence AI Council with Hon'ble Raksha Mantri as Chairperson and Defence AI Project Agency with Secretary DP have been formed. However, to succeed, it is essential that AI is first understood in the correct perspective in the Armed Forces. Towards this end, a 'Primer on AI for Armed Forces' has been prepared to catalyse coherent actions for harmonised development and employment of AI-enabled systems. It is also intended to give a broad insight to the Services at all levels into this strategically significant technology.



4. HQ IDS in consultation with Service Headquarters has already formed a Joint Working Group on AI. Once sufficient traction is built, HQ IDS would prepare a Joint Doctrine on AI. Whilst Services - Academia - Industry connect would play a key role in inducting AI into the Indian defence construct, it is the Armed Forces themselves who have to steer the induction of AI into the Services on utmost priority.

02 Mar 2020



(R Hari Kumar)
Vice Admiral
CISC



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INTRODUCTION

Hon'ble Finance Minister, in his budget speech for 2018-19 mandated NITI Aayog to establish the national programme for Artificial Intelligence (AI). Accordingly, in the strategy document published by NITI Ayog, a new term “**AI for ALL**” was brought forward. The aim being enhancing and empowering human capabilities to address the challenges of access, affordability as well as shortage and inconsistencies of skilled expertise. In other words, AI Strategy is aimed primarily at guiding an inevitable wave of change fueled by a revolutionary technology for a quick impact on society¹.

In line with the national approach towards development of AI, Ministry of Defence (MoD) constituted a taskforce in February 2018, headed by Mr N Chandra Sekaran, Tata Sons Chairperson. The Task Force studied the level of AI or Machine Learning (ML) development in India, mainly in context of defence needs and suggested its use in the area of aviation, naval, land systems, cyber, nuclear and biological warfare. The study concluded that AI can fuel technology driven economic growth. It also has potential to provide military superiority and to have a transformative impact on national security².

¹ NITI Aayog Discussion - National Strategy for AI Jun 2018, p5.

² MoD AI Task Force Report - June 2018.



Information Technology (IT) has been at the forefront of Revolution of Military Affairs (RMA) in the Armed Forces across the globe. Modern improvement in Information and Communication Technology (ICT) has potentially altered the nature of conflicts, to make them swift, lethal, intense, precise, un-demarcated, undeclared, multi-faceted, multi-dimensional, increasingly integrated and non-contact. This has spawned new concepts such as Network Centric Warfare, Cyber Operations, etc. AI has a huge potential to transform future warfare and therefore AI-enabled RMA, which has the ability to mimic human cognitive functions looms large on the horizon. AI and digital innovation will therefore have to work in tandem to bring in transformational changes to the strategic military landscape.

AI has been in vogue as an academic discipline for a while, however this predictive “enabler/ tool” has only very recently gained impetus. This has been largely attributable to the proliferation of internet, cheaper hardware, increased data volumes, computing power and advanced algorithms. AI is widely acknowledged as a “game changer” which is likely to change the rules of the game in the Armed Forces keeping in view the nature of future conflicts, emergent concepts and military applications widely believed to be the harbinger of the next RMA. In recent years, there has been a thrust on exploring the use of data-driven neural-network-based Deep Learning (DL), in improving our offensive and defensive capabilities. The transformative nature of AI needs to be explored and driven in a “mission mode” by the Indian Armed Forces, academia, research



organizations and industry to stay at par with technological developments resulting from induction of AI in all components of National Power including the military.



ARTIFICIAL INTELLIGENCE : AN OVERVIEW

Artificial intelligence (AI) is a rapidly growing field of technology with potentially significant implications for national security; however, its substantive induction in Armed Forces has yet to be achieved. AI is revolutionary and not evolutionary. It therefore works on a paradigm shift from the existing technologies and conceptually requires a thorough understanding of its fundamentals. Without proper understanding and a viable roadmap, AI technology absorption as a force multiplier may not be feasible. Examples of isolated use of AI applications does exist in the Armed Forces, but using this complex, all-pervasive technology as a game changer would only be feasible if military planners have a clear understanding of its concepts as well as potential. This would give them clarity on what they desire and how to proceed. Although a centralized push for AI may result in a big win, poorly conceptualized hurriedly inducted AI applications could easily result in epic failures³. Hence, this important technology requires a multi-disciplinary perspective for a better understanding of its adoption and the consequences.

³ A Primer on Artificial Intelligence for Military Leaders by Stoney Trent and Scott Lathrop.



What is AI?

John McCarthy coined the term AI in 1956 at the Dartmouth conference, Massachusetts Institute of Technology. AI might just be the single largest technology revolution of our times, with the potential to disrupt almost all aspects of human existence⁴. All academic studies in AI acknowledge that no commonly accepted definition of AI exists and that the definition is still evolving with advent of this transformational technology. Although, field of AI research began in 1956, an explosion of interest in AI began around 2010 due to the convergence of three enabling developments, firstly, the availability of ‘big data’ sources, secondly, improvements to ML approaches and thirdly, substantial increases in computer processing power⁵.

To put simply, AI is composed of two words **Artificial** and **Intelligence**, where Artificial defines "*man-made*," and intelligence defines "*thinking power*", hence AI means "*a man-made thinking power*." To amplify, it is the concept of machines acquiring human-like intelligence, which generally follows a

⁴ Discussion Paper by NITI Aayog on National Strategy for Artificial Intelligence, June 2018, p12.

⁵ CRS Report, Artificial Intelligence and National Security, Updated January 30, 2019.



sequence known as the perception–cognition–action (or decision making) information processing loop⁶.

In general, there are three tiers of AI that can also be seen as three consecutive generations or levels of AI:-

- **Artificial Narrow Intelligence** (ANI or “narrow AI”) is machine intelligence that equals or exceeds human intelligence for specific tasks, as it is limited to a single task or set number of tasks.
- **Artificial General Intelligence** (AGI or “strong AI”) is machine intelligence meeting the full range of human performance across any task in a wide range of environment.
- **Artificial Superintelligence** (ASI) is often used to refer to general and strong AI at the point at which it surpasses human intelligence.

To comprehend nuances of AI, it is important to distinguish between an **automated** and an **autonomous** system. An automated system is one in which a computer reasons and for each input the system

⁶ Jeremy Owen Turner, Michael Nixon, Ulysses Bernardet, Steve DiPaola (eds), “Integrating Cognitive Architectures into Virtual Character Design”, *Information Science Reference*, Hershey: IGI Global, p 239.



output will always be the same. An autonomous system is one that reasons probabilistically given a set of inputs, meaning that it makes guesses about best possible courses of action given sensor data input. Unlike automated systems, when given the same input autonomous systems will not necessarily produce the exact same behaviour every time; rather, such systems will produce a range of behaviour⁷.

AI Defined

AI can be defined as the ability of computers to perform mental tasks that human beings perform using their acquired skills, experience and knowledge⁸. AI facilitates quicker decision-making and predicts the right decision in the given circumstances, based on the historical data, experience and current trends⁹. It is only an “enabler/ tool” and not a “weapon” as such. ML algorithms detect patterns and learn how to make predictions and recommendations by processing data and experiences. The algorithms also adapt in response to new data and experiences to improve efficacy over time.

⁷ Military Applications of Artificial Intelligence by Deepak Kumar Gupta (CLAWS), 17 March, 2018.

⁸ AI Task Force Report Ministry of Defence, Government of India, June 2018, p6.

⁹ Feedback on Workshop on AI conducted by Indian Defence University and Military Institute of Technology at New Delhi from 11 - 13 Sep 2018, p2.



AI Applications

AI has become widely popular and gained prominence due to its multifaceted application ranging from healthcare to military devices. We can now expect AI systems to achieve human level or better performance in a variety of cognitive tasks such as:-

- Tasks requiring **Perception** and **Understanding**, for instance, recognizing objects, faces and text, transcribing voice to text, or summarizing documents and translating language.
- **Prediction Tasks**, for instance, detecting as well as forecasting a machine failing.
- **Prescriptive Tasks**, for example, making complex decisions. These are tasks for which optimal solutions are in principle mathematically computable but in practice computationally intractable and which humans manage quite well using experience and 'gut feel'.
- **Participative Tasks**, for example, physical machines (robots) operating autonomously in the real world.



Currently certain advanced AI capabilities are in various stages of development and usage and include natural language processing, searching information, facial, object or gesture recognition, machine vision, self-adaptive learning, intuitive perception, comprehensive reasoning, hybrid intelligence (man-machine combined intelligence), collective swarm intelligence, problem solving, prediction and response, among others¹⁰.

Advantages of Artificial Intelligence

Following are some main advantages of AI:-

- **Accuracy** - AI systems are prone to less errors and high accuracy rate as they take decisions based on pre-fed data.
- **High-Speed** - Current technological advancements have enhanced computing speed manifold.
- **Reliability** - Due to minimal human interface, AI systems have high rate of consistency in their output.

¹⁰ Munish Sharma, “The Global Race for Artificial Intelligence: Weighing Benefits and Risks”, *IDSa Issue Brief*, available at https://idsa.in/issuebrief/the-globalrace-for-artificial-intelligence_msharma_230218 (accessed 14 Oct 2019).



- **Risk Factor** - AI machines can be helpful in situations, which have high risk factor, such as, defusing bombs, space exploration, etc.
- **Public Utility** - AI has major relevance in sectors such as healthcare, manufacturing, financial technology, agriculture, education, customer engagement, national security, etc.

Disadvantages of Artificial Intelligence

Every technology has some disadvantages, and AI is no different. Following are the disadvantages of AI:-

- **High Cost** - R&D, initial fielding and maintenance costs of AI systems/ technologies are reasonably high.
- **Trained Work Force** - absorption of such advanced technologies would require skilled work force with adequate training.
- **Lack of Emotions** - AI systems would produce results as per what they are trained without emotions attached. This may lead to trust deficit in outputs if due care is not taken. As a normal, human beings are less likely to trust autonomous systems in comparison to manned ones.



- **Increase Dependency on Machines** - People over time are becoming more dependent on technology, thus any breakdown or corruption in system may lead to a catastrophic effect.



MILITARY APPLICATIONS OF ARTIFICIAL INTELLIGENCE

Countries around the world are becoming increasingly aware of the potential use of AI technology, with most governments significantly increasing funding for AI systems. Super Powers are pursuing development of AI technology from a national strategic perspective and investing billions of dollars in this field¹¹. Their rise as major powers in AI has a potential to become a vital “force multiplier” for future military capabilities¹². AI is already reshaping the functioning of militaries in a major way. It will radically transform future warfare and military operations¹³. Military leaders and strategists believe that the character of war is fundamentally changing to unmanned platforms and autonomous systems. They have labelled AI research as a national priority thus giving it a huge boost¹⁴. Most of the new patents and startups in AI are in the US, China and Japan with remainder in Europe.

AI is a disruptive technology, which will bring in transformational changes to the strategic military landscape and provide multiple options for military

¹¹ Lt Gen (Dr) RS Panwar, USI Monograph No 2 - AI in Military Operations, p36.

¹² MoD AI Task Force Report - Jun 2018 p25.

¹³ Future Warfare and Artificial Intelligence, The Visible Path; IDSA Occasional Paper No : 49, August 2018 by Atul Pant.

¹⁴ <https://www.uscc.gov/sites/default/files/Research> (accessed on 30 Sep 2019).



applications at strategic, operational and tactical level by being functional enablers for Armed Forces to operate in multi-domain hybrid environments. The Armed Forces need to understand the scale and pace of this change to ensure that the response is adequate and not piecemeal or incremental. Accordingly we need to conceptually and structurally develop capabilities in niche enablers like AI to equally adapt to this transformational change.

Whilst AI is advancing at a rapid pace, however the current struggle to provide computers with true knowledge and expert based behaviour, as well as current limitations in perception sensors, will be many years before AI will be able to approximate human intelligence taking into consideration the fog and friction of war¹⁵. Although the current shortcomings present challenges to adoption of AI by the military, there is little doubt that our defence forces have to, without delay adopt AI for many military applications for development of systems for future wars, especially for non-contact warfare, i.e, Cyber, Space, Laser, Electronic Warfare (EW) and Robotics¹⁶. Therefore, current military planners need a sound understanding of AI in the strategic context. This would enable them to identify requirements wherein the tools of AI along with robotics could combine to empower our

¹⁵ <https://www.chathamhouse.org/org> (accessed on 24 Sep 2019).

¹⁶ Address by General Bipin Rawat, Chief of Army Staff and Shri Ajit Doval, NSA during inaugural session of 41st DRDO Directors' Conference on 15th Oct 2019 at DRDO Bhawan, New Delhi.



defence forces¹⁷. These along with Internet are the drivers of the fourth industrial revolution. A clear vision of the AI programme would also rationalise financial investment in this sector, which would inevitably be a key factor for a middle-income country like India¹⁸.

Augmentation of Ongoing Non-Lethal AI-enabled Operational Applications

Induction of AI-enabled technology would be dictated by operational requirements. Some of the applications (but not limited to), which can be pursued concurrently are as given below:-

- Cyber Security - systems equipped with AI can autonomously protect networks, computers, programs, and data from any kind of unauthorized access.
- ISR - AI can be applied for effective processing of sensor data and raw intelligence, which incorporates intelligent sensing, and automation of multi-sensor data fusion to enhance situational awareness. This

¹⁷ Present and Future Unmanned Aerial Systems, How AI can Change the Paradigm by Lt Gen VK Saxena; South Asia Defence Strategic Review, Vol 12, Issue 3, Jul-Aug 2018.

¹⁸ Artificial Intelligence in Military Operations: Where does India Stand by Ambuj Sahu, 02 Aug 2019; <https://www.orfonline.org> (accessed on 10 Oct 2019).



information will assist in military forecasting and risk prediction.

- Image interpretation for target identification and classification.
- Threat modelling and situational awareness - Unmanned Aerial Vehicles (UAVs) with integrated AI can patrol border areas, identify potential threats, and transmit information to ground station. Using UAVs can thus strengthen the security of military bases, border areas, coastal areas, etc.
- Enhanced use of robots for neutralization of Improvised Explosive Devices, Mine Detection, Mine Field Breaching, and other such applications.
- Threat modelling and war-gaming simulation.
- Expert systems for diagnosis and predictive maintenance.
- Miscellaneous AI applications such as Cognitive Radios, Integrated Security Systems, video, audio and speech processing.



Augmentation of Ongoing Non-Lethal AI-enabled Support Applications

AI applications have a wide scope for utilization in support functions of the Armed Forces. These are enumerated below:-

- **Logistics (including Op Logistics)** - This is arguably the lowest of the low hanging fruits available to the Indian military. Substantial work has already been done in deploying AI for logistics and supply chain management in the civilian sector, with several Indian companies also having built considerable expertise in this area¹⁹. E-Commerce companies have proven that AI-enabled applications can be extremely useful in inventory and logistics management using Big Data Analytics. These can be used for logistics allocation, analysing replenishment cycles, transport management, etc. AI will be a useful tool for predictive maintenance as well as pre-emptive maintenance, repair and maintenance of equipment and many such fields. It can be seen that AI enabled systems can revolutionise logistics and maintenance management.

¹⁹ How AI can help the Indian Armed Forces by R Shashank Reddy; Ksgindia.com /index.php/study-material/ today-s-editorial/ 13440-11-march-2018.



- **Medical** - AI can be integrated with medical diagnosis, Robotic Surgical Systems (RSS) and Robotic Ground Platforms (RGPs) to provide remote surgical support and evacuation activities. Under difficult field conditions, systems equipped with AI can mine soldiers' medical records from central database and assist in complex diagnosis²⁰.
- **Finance and Accounts** - AI applications can be used in financial accounting, auditing and fund allocation. It can also be utilized in anomaly detection that can bring out efficient finance management through better transparency and highlight shortcomings in the existing processes. AI led applications have huge potential in monitoring expenditure in the Armed Forces.
- **Human Resource** - AI applications can be effectively used in recruitment systems, career management, behavioural management, postings, discharge, record keeping, public relations, etc. AI-enabled tools, if used effectively can be of substantial help in

²⁰ 8 Key Military Applications for Artificial Intelligence in 2018 by Tejaswi Singh and Amit Gulhane; October 3, 2018, <https://blog.marketresearch.com/8-key-military-applications-for-artificial-intelligence-in-2018> (accessed on 10 Oct 2019).



ensuring efficient HR management, leading to a better and healthier working environment and performances that are more efficient.

- **Public Relations** - AI can act as a virtual editor.

Development of New Non-Lethal Applications for Operational Purpose

Once the nascent AI applications/ systems mentioned above have been tried, tested and vetted by user trials, quality control and inspection agencies, they could be integrated in a large scale manner across the armed forces. Subsequent steps could entail development of the following:-

- Offensive Cyber Operations.
- Unarmed Underwater Vehicles.
- Swarming of Surveillance Drones.
- AI enabled Security Sentry Robots.
- Swarm Drone Boats.



Development of Lethal AI-enabled Systems

While the latest operational systems are more automatic than autonomous, there are significant efforts in the R&D of autonomous systems. Incremental progress in such military system development is occurring in many countries in air, ground, on-water and underwater vehicles with varying degree of success. However, as far as development of Lethal AI Weapons is concerned, international norms and regulations should be paid due cognisance to ensure a civilised global order, taking into consideration current debates within the United Nations Convention on Certain Conventional Weapons on Lethal Autonomous Weapon System (LAWS) and their ethical, legal and moral implications. There is considerable stress upon importance of “human-in-the-loop” in any AI-enabled system. Therefore, whilst the debate over whether autonomous weapons should be banned is clearly an important one, an immediate issue is the ability of our defence industry to provide safe semi-autonomous systems, much less fully autonomous ones²¹. This is critical if we are not to be disadvantaged by our potential adversaries.

²¹ Artificial Intelligence and the Future Warfare, Defence Technology, The Technical Journal of The Army War College, Jan 2018, Volume 47.



IMPLEMENTATION OF AI IN ARMED FORCES

Formulation of Policy

There is a requirement to have a policy in place at the apex level in the Armed Forces to give adequate impetus for broad based implementation of AI. The policy should aim to integrate AI into capacity building programmes undertaken by the SHQs/ HQ IDS, duly coordinated by HQ IDS in close consultation with various ministries, departments, academia and industry to achieve identified objectives.

Focus Areas

Focus areas, both involving joint and single Service could be as mentioned below²²:-

- Improve offensive and defensive war-fighting capabilities in all domains.
- Improve ISR capabilities.
- Efficient and quick decision-making post assessments based on audited data.

²² MoD AI Task Force Report - June 2018, p35.



- Enhance support capabilities, such as, of logistics, infrastructure, human resources, medical, financial management, etc.
- Analysis of social media.
- Efficient disaster management.
- Ensure suitable recruitment and training of Armed Forces personnel in AI.
- Source innovation in defence applications from Private Sector and Start Ups by leveraging our science and technology base to rapidly scale up our AI capacities by developing dual use indigenised technology.
- Enforce legal, ethical, auditable and moral safeguards of using AI to ensure compliance with international commitments and national legal framework.

Capacity Building

There is a requirement for the Services to incorporate AI component (AI at “Edge”) in maximum applications, which in turn would assist joint Services applications (AI at “Core”) to enable the SHQs and the stakeholders to operate in an integrated manner. If incorporation of AI at the ‘edge’ is not viable currently due to need for computing hardware, AI based inputs



should be processed at the back end, which in turn would require better networking in the field. Towards this end, it is essential that the Armed Forces identify a common network that would enable utilising a common database and development of ML algorithms to leverage the same. Even while Defence Communication Network (DCN) could be designated as the single network for hosting the Tri-Service AI framework, having de-centralised approach with each Service structuring, collating, assimilating and processing data would be an easier system to architect. This is considering the fact large variance of environment of operations and consequently variance in data generated and analysis/ optimisations required. Once data is structured, access of data across Services would be easier to incorporate.

There is a need to build and augment “dual-use” AI (for use in both military and civilian sectors) where some tangible progress has been achieved for embedding AI in the existing military platforms.

We must build capacities in order to meet our envisaged capability requirements. Towards this, due cognizance needs to be paid to the under mentioned aspects:-

- **Disruptive Technology** - AI is a disruptive and complex technology and is as good as “Data” and “System” in which the former is fed. Algorithms are presently based on open source data and are vulnerable to fudging or



bias, a factor that will need to be carefully analysed.

- **Future Procurements** - Whilst future procurements should cater for incorporating AI at the initial stage to the extent feasible, this would in many instances require high speed networking infrastructure.
- **Budget Allocation** - AI technology is currently expensive and therefore the same should be accorded the status of Special Vehicle Projects. Additionally, feasibility of earmarking minimum 5% of budget in a scaled manner, towards development of AI-led applications may be explored by the SHQs. This has been recommended in the AI Task Force Report of the GoI.
- **Reliability and Safety** - Appropriate regulatory mechanisms need to be in place. Legal and ethical guidelines relating to AI enabled systems and their usage by the Armed Forces must be clearly spelt out. These safeguards should be designed in a manner, which allows us to exploit these technologies to the maximum and at the same time prevent others to gain access to our information/database/ technologies. Further, comprehensive trials, testing and certification should be resorted prior to induction of AI



applications. There is a necessity to draw required standards/ policies/ protocols for this.

- **Open Source Commercial Software** - AI projects, especially in the area of non-contact warfare and networking/ C3ISR, are highly security sensitive in nature. Tweaking of algorithms, incorporating trapdoors, Trojans, etc by adversaries/ unethical vendors, can play sufficient havoc with implications as severe, if not more than actual contact warfare. Therefore, use of open source commercially available software needs to be thoroughly evaluated from security perspective prior utilising them in defence applications.
- **Domain Knowledge/ Awareness** - DRDO has moderately good technological base. It needs to be impressed upon to speed up development of expertise in these areas. There is also a pressing need to synergise with the expertise now available within the academia and the industry within India. Towards this, DRDO has a well developed mechanism for involving academia through extramural projects and also funding Micro Small and Medium Enterprises (MSMEs) and Start Ups through a Technology Development Fund (TDF). This needs to be exploited to its full potential.



- **Transformation of Mind-Sets** - A key enabler would be transformation of “mind-sets” within the Armed Forces, which would have to be pursued relentlessly.
- **Inclusivity** - An “all inclusive” approach involving stakeholders will hold the key to usher in AI technology. This is the key to achieving a rapid induction of AI in the Armed Forces, since AI is a highly collaborative domain.
- **Adherence to Timelines** - Obsolescence of ICT and AI technologies is extremely rapid and it is entirely feasible that unless the gestation, acquisition and roll out timelines are not shortened, the AI applications being inducted would be obsolete even prior to induction. Usually development agencies (particularly Government ones), impress Services to accept systems even without meeting complete General Staff Qualitative Requirements (GSQRs). The Forces on the other hand refuse to accept any system until all GSQR are met, even though it may be realized during the development period that the GSQR is unrealistic or far too futuristic and well unreachable within the capability of the development agency. The development agencies are usually guilty of over promising, while Services are usually guilty of being unrealistically ambitious in drawing the QRs.



This can be avoided by utilizing a progressively graded model for development of military weapons and systems. This is successively adopted in many countries with development divided into ‘Marks’ or ‘Blocks’. This can be mutually decided and development of an upgraded ‘Mark’ or ‘Block’ can be commenced on a sliding basis prior to completion of the delivery of the previous one. This would improve delivery timelines as well as result in better development risk management. Further, Armed Forces and R&D community have to work together to bring the system to desired levels²³. For AI projects to remain relevant, there is a pressing need to authorize speedy or ‘Fast Track’ acquisition process. The present timelines for capital acquisition as per DPP 2016 are incompatible with induction of ultra-rapidly evolving technologies such as AI.

The Armed Forces, Industry, Academia, Defence R&D agencies, will have to be identified and they will have to work closely in a cohesive manner as “a consortium” or in a collaborative approach, to build capacities, especially indigenised in a wholesome manner. Synergy between Armed Forces and Defence R&D community can be achieved by embedding Service officers at all stages of R&D, so that success and failures

²³ Address by General Bipin Rawat, Chief of Army Staff and Shri Ajit Doval, NSA during inaugural session of 41st DRDO Directors’ Conference on 15th Oct 2019 at DRDO Bhawan, New Delhi.



becomes a joint responsibility. This concept of synergy can be extended to production and life cycle phase as well²⁴. Stakeholders will have to ensure the following:-

- **Big Data Management** - No matter what AI strategy we deploy, well-organised data is a critical foundation for success.
 - **Availability/ Accessibility** - All applications will be data heavy since ML algorithms are designed to learn from patterns in source data. Therefore, availability/ accessibility of intelligent/ relevant Big Data in a “digitized form” (to reduce time for searching documents) would be the primary driver. If data is unavailable, the same will have to be procured from reliable sources. Similarly, we will have to unlock the “value” trapped in vast volumes of data, which will be useful for DL. Further, aspects of data collation and preparing the data for usage will need to be addressed by each stakeholder. It must however be borne in mind that data at times, may be “polluted” due to record-keeping flaws, historic trends, etc.
 - **Creation of Tri-Services Database and Framework** - A common database and

²⁴ Ibid.



suitable framework would have to be created for storage of data sets pertaining to areas of Tri-Services interests.

- **Sharing of Data** - All stakeholders would have to be mandated to share their data by a Regulation/ Data Sharing Agreements/ Management of Frameworks on as required basis. If necessary requisite legislation may have to be enacted. Whilst sharing of classified data between the government departments is conducted under well established procedures, sharing of data with business entities would require 'Confidentially and Non-Disclosure Agreements (CNDA)'.
- **Convergence of Data** - Stakeholders would have to be able to converge and make sense of data from sources such as Internet of Things (IoT), sensors and social networks.
- **Data Annotation/ Structuring** - It is crucial since the requirement of tagged/ annotated/ formatted data is required for AI. As of now, technological advancements are not at a level where manual annotation can be replaced²⁵.

²⁵ NITI Aayog Discussion Paper, National Strategy for AI, p80.



- **Analysis** - High-speed processors and new services based software for analysis of data (Super Computing, Quantum Computing and Big Data Analytics) would need to be incorporated.
- **Net-Centricity** - Net-centricity/ digital connectivity is a pre-requisite for success of AI. This would need to be progressed on an accelerated basis with concerted efforts to induct military/ civil satellites. “Captive Cloud” (dedicated Tri-Services server) computing would make communication and data transfer seamless, secure and fast thereby enabling hosting applications for Service use in the Captive Cloud. The real power of net-centricity is based on its reach and traffic and this is affected considerably by the applications that are available for use.
- **Infrastructure Ecosystem** - Scaling of existing infrastructure like Data Centres, Test beds, etc, along with availability of adequate processing power, data storage/ management solutions and information security overlay would have to be ensured. We may also consider utilizing a Public-Private Partnership model to exploit the infrastructure available in the environment, incorporating adequate security safeguards.



Investment in Research and Development - As and when, AI-enabled technology gains momentum, it would be possible to significantly reduce the “teeth-to-tail ratio”. This would in turn lead to savings and these “matching savings” in turn can be utilised towards R&D for development of advanced AI-enabled technology. Indian manufacturers will need to increase their investment in R&D and in turn need to be incentivised by the Government²⁶. Furthermore, the existing ecosystem for Defence R&D should be incentivised for effectively tapping the potential of premier academic and research institutions of the country in this domain. There is a need for a strong synergy between the Government, Armed Forces, DRDO, PSUs, industry and the academia. The Armed Forces can also explore active collaboration with private industry and other premier Technological and Research Institutes. The users of the systems should be involved in every stage of development and trials.

Sourcing AI Innovation - India has various Start Ups that are working in the area and have developed successful AI applications in various fields. We can take advantage of currently available AI capabilities in the market to accelerate AI adoption in our areas of interest, as deemed appropriate.

Data Protection and Intellectual Protection Rights - Appropriate Data Procurement Agreement/ Intellectual Protection Rights must be signed between the

²⁶ Lt Gen (Dr) RS Panwar (Retd), USI Monograph No 2 - AI in Mil Ops, p43.



Armed Forces and all stakeholders to maintain confidentiality to address any breach of security. This would involve a careful analysis of legal and ethical implications, including privacy of using AI for military purposes. It should however be borne in mind that Intellectual Property Rights should not be unduly fettered, as this be a deterrent to incentivise research and adoption of technology. Mandating data accountability from developers and users is expedient. We could develop audit mechanisms to inspect whether the algorithm meets the intended purpose, and whether it discriminates between similarly placed situations.

Perspective Plans - The Perspective Plans Directorates of the Indian Army, Indian Navy and Indian Air Force would need to work in close coordination, while preparing respective LTTPs prior vetting by HQ IDS for finalising the LTIPP. Given the pioneering nature of AI technology and its far-reaching implications in changing the nature of warfare, there is a need to constitute a Tri-Services AI Committee. This committee could vet and finalise Joint Service Qualitative Requirements (JSQRs) for common use AI applications, to ensure integration between the Services, right from the planning stage. Working Groups can be formulated under the Committee to address specific tasks or areas of concern. Professional agencies may be engaged through consultancy to provide specialist inputs, which may be unavailable with the Armed Forces.

Technology enabled by AI would have to be included in the LTTP of the SHQs. Due diligence is to be



exercised when embedding AI into the weapon or other systems. This in no way means that it is to be avoided. On the contrary, AI induction is to be encouraged on a fast track basis. However, considering the very nature of this technology, stringent norms for security are to be applied from the design stage up to its actual operation. On the maintenance side, all new induction equipment must have AI-enabled features such as predictive maintenance to result in significant life cycle savings. There is a requirement to establish formal AI incubation cells with the three Services.

Human Resource Development

- **Training/ Skill Upgradation**
 - A full-fledged Defence AI University may not be warranted at this stage. However, a Centre of Excellence can be created in the planned Indian Defence University (IDU). In addition to civil institutes, strength of institutions under MoD needs to be gainfully utilised. For example, until IDU is well established, DIAT being a deemed university may be utilized for collaboration with foreign universities. Thus, DIAT may be tasked to organise tailor made courses on AI in collaboration with some of the leading universities of the world, such as, Stanford Artificial Intelligence Laboratory (SAIL), etc.



- More than anything else, there is a requirement to provide a clear understanding of AI, its application as well as limitation to the leadership and the officer cadre of the Armed Forces.

- In the ensuing years, military personnel at all levels will require basic literacy in AI, including knowledge of its applications and how to optimally combine it with human intelligence. Furthermore, any skilled workforce using AI should be a judicious “mix” of those with a basic understanding, more informed users, and specialists with advanced skills. Towards this end:-
 - Domain knowledge, ie, Computer Science, mathematics, electronics and Robotics is very important. Accordingly, our personnel policies should focus on identifying suitably qualified candidates and sponsor them for long-term courses leading to various kinds of professional diplomas and degrees²⁷.

 - Study leave on the subject should be encouraged. Small training capsules

²⁷ MoD AI Task Force Report - June 2018, p68.



(including on-line) can also be held on frequent basis for desirable candidates.

- Lateral induction of defence civilians or deputation from PSUs/ DPSUs/ Ministries with AI background and expertise to the Armed Forces could be explored.
- All the three Services have dedicated Training Commands. These Command HQs can also be tasked for creation of Schools, Establishments and Centres of Excellence to boost training and awareness in AI in close coordination with respective SHQs.
- AI can also be introduced as a separate subject in various schools of instruction at all levels.
- War games need to be conducted in a network-centric environment with AI enmeshed for realistic training.
- **Manpower Planning and Recruitment** - The recruitment of both officers and PBOR, needs to be aligned with AI technology. For example, Robotics can be introduced as a qualification for gaining technical officer entry into the Armed Forces. Induction on



“contract basis” of skilled work force can also be considered to bridge critical technology gaps.

Opportunities

AI affords many advantages for its exploitation in almost every sphere of military activity, be it operational, support or administrative in nature. Its judicious and optimum utilisation can accrue many advantages to the Armed Forces.

- **Sound Judgement** - AI can reduce reliance on human judgement that is prone to “bias”, thereby making judgements based on facts leading to enhancement of reliability factor.
- **Quick Decision Making** - The capacities of AI-enabled systems to handle and analyse large volumes of data in real time, would enhance speed and reach, which in turn would shrink the OODA loop as also obviate VUCA. As AI offers a means to cope with an exponential increase for data available for analysis, it will eventually lead to information superiority.
- **Cost Effectiveness** - While AI enabled systems, do require their own infrastructure, however, once it is in place and functioning, it



will entail less infrastructure, human involvement and maintenance.

- **Synergy** - Increased synergy or human-machine interface.
- **Safety of Equipment/ Systems** - AI has a vast potential of increasing the safety of the operating systems in various platforms like aircraft, ships and submarines operating in a complex and dynamic environment by providing “alerts” to hidden dangers, risk prediction and predictive maintenance.
- **Minimal Collateral Damage** - Incorporation of AI will improve sensory inputs and decision to drive precision strikes thereby minimising collateral damage.

Challenges

Incorporation of AI in Armed Forces remains a challenge, in view of existing difficulties, lack of infrastructure and limited understanding of the concept. Some of these are as mentioned below:-

- Availability, storage, accessibility, filtering and sharing of authentic and trained digitalised data coupled with embedding the same into computer systems with adequate checks.



- Protection of data to preclude poisoning, cyber attacks, alteration, modification, content forgery, impersonation and theft. Phishing and hacking are a major concern.
- Lack of adequate capacity, viz, adequately trained personnel, infrastructure and R&D facilities necessary for capability development.
- Retention of “human loop” is important for defence applications.
- While ML has recorded impressive results, a key challenge is the “bias” which creeps into a machine from the training data fed by human beings.
- No code of conduct, legislations, certifications and legal framework.
- Allocation of adequate funds within the existing budget.
- Challenges with respect to ease of adaptability of commercial AI technology for military purposes. Commercial AI present another challenge to the integration of military AI due to issues related to standards of safety and performance, acquisitions, and intellectual property and data rights. Often, civilian and



military standards of safety and performance are either not aligned or are not easily transferable.

- Very limited network connectivity. Even where it is available in the Armed Forces, it may not be of the required quality and reliability.



WAY AHEAD

Tri-Services AI Committee

Dr Chitra Rajgopal, DS, DG (SAM) & DG (R&M) has commented, “Our neighboring countries have gone far ahead in the field of AI, and there is a pressing requirement for us to have a clear cut roadmap laid out for development and implementation of AI and towards this aim there is a need for formulation of an expert forum.”²⁸ Accordingly, Joint AI Committee for coordinating Tri-Services issues in respect of capacity building and capability enhancement needs to be established. The responsibilities of this Committee should include but not be limited to functioning in close consultation with Defence Artificial Intelligence Council (DAIC) under chairmanship of Hon’ble RM and Defence Artificial Intelligence Project Agency (DAIPA) constituted under the Department of Defence Production (DDP) duly interfaced with other stakeholders to streamline sanction and execution of AI projects and subsequent utilization by Armed Forces. Other responsibilities could be as follows:-

- Provide strategic direction towards adoption of AI in Indian Armed Forces.
- Foster collaboration and synergise efforts in design/ development and production of AI-

²⁸ Opening remarks by Patron and Chief Guest Dr Chitra Rajgopal, DS, DG (SAM) & DG (R&M) in seminar on “Application of AI in Defence Modelling & Simulation” conduct by ISSA, DRDO at Metcalfe House Complex, New Delhi on 09 Sep 2019.



enabled systems across the three Services and DRDO, Defence Public Sector Undertakings and industry on focus areas. Priority should be on development of indigenous technology, share learnings and avoid duplication.

- Provide guidance to IDU and Tri-Services AI training establishments.
- Formulate Standard Operating Procedures/ best practices for development/ delivery of AI based projects, solutions sharing/ security of data including preferred, technology stack, reusable technology and standard processes, shared data, expertise, etc, to enable rapid delivery and scaling of AI enabled capabilities in the Services in consultation with MoD, SHQs, DRDO, industry and academia.
- Periodic review and re-assessment of AI-enabled systems and planning for future requirements.
- Review the suitability of available AI professionals and measures undertaken to keep them “current”.
- Provide inputs for formulation of IPR policies to DAIPA.
- Take up emerging Tri-Services suggestions, issues and problems faced for progressing AI projects at an appropriate level.



- Undertake AI HR Consultancy through industry and academia to engage a professional agency to assess the requirement of trained AI work force including (if required) the necessity for a separate AI cadre for development, management and operation of AI infrastructure.

Steps for Capability and Capacity Enhancement

Strategic thinking on advances in military applications of AI is the need of the hour²⁹. Certain steps, which could be undertaken by stakeholders, are as suggested below:-

- As Armed Forces, there is a requirement to jointly formulate mission oriented long-term policy for critical strategic AI technologies. A concise roadmap for short, medium and long-term applications of AI in sync with technological advancement needs to be put in place and promulgated.
- Identify the threats and focus areas wherein AI can be used as a “Transformative Technology” on a continual basis. Accordingly, we must identify the use cases and key capabilities, which can address our focus areas.

²⁹ Military Applications of Artificial Intelligence by Deepak Kumar Gupta (CLAWS), March 17, 2018.



- Spread awareness on latest technologies available as well as technologies in developmental stages that can be utilised in the Armed Forces.
- Build and strengthen Armed Forces – Civil & Defence R&D - Industry - Academia - Centres of Excellence connect.
- Adopt a Legislation or a Code of Conduct for sharing of data, protection of data, IPR issues, privacy, ethics, etc, to promote user trust.
- Revamp and re-organise Branches, as required in the SHQs and HQ IDS for smooth functioning and avoiding duplication.
- Build capacity (especially indigenised) and enhance capability (by adopting an “integrated” and “incremental” approach) in consultation with all stakeholders. Towards this, net-centricity would be an important enabler.
- It is essential to meet timelines in all AI development projects. If the timelines are not being met for any reason, redefine



technological goals in synchronisation with prevailing national security requirements³⁰.

- Requisite budget allocation considering “dual use technology”.
- Close monitoring by institutional mechanisms and responsible oversight.

³⁰ Address by General Bipin Rawat, Chief of Army Staff and Shri Ajit Doval, NSA during inaugural session of 41st DRDO Directors’ Conference on 15th Oct 2019 at DRDO Bhawan, New Delhi.



CONCLUSION

On July 20, 2017, the Chinese government released a strategy detailing its plan to take the lead in AI by 2030. Less than two months later Vladimir Putin publicly announced Russia's intent to pursue AI technologies, stating, "Whoever becomes the leader in this field will rule the world."³¹ Similarly, the US National Defense Strategy, released in January 2018, identified AI as one of the key technologies that will "ensure the United States will be able to fight and win the wars of the future."³² It is anticipated US will spend USD 5 Billion on AI R&D activities by 2020.³³

It needs no reiteration that AI is going to be a part of all components of National Power, viz, Diplomacy, Information, Military, Economy, Political and Social. In the Armed Forces, AI will have to decipher data using cognitive data/ technologies designed to understand and complete many of the tasks that Armed Forces have manually undertaken in the past and enable them to

³¹ China State Council, "A Next Generation Artificial Intelligence Development Plan," July 20, 2017, translated by New America, <https://www.newamerica.org/documents/1959/translation-fulltext-8.1.17.pdf>.

³² US Department of Defense, *Summary of the 2018 National Defense Strategy*, p.3, <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>.

³³ Talk by Lt Gen (Dr) RS Panwar (Retd), in a seminar on "Application of Artificial Intelligence in Defence Modelling & Simulations" conducted by ISSA, DRDO at Metcalfe House, New Delhi on 09 Sep 2019.



undertake several others hitherto out of the reach or ability of the Armed Forces. Its ability to improve the speed and accuracy of most activities and processes, shorten timelines and improve accuracy in all military planning - from logistics to battle space, as well to assist in improved human decision-making, underlines the fact that AI is the key to future warfighting.

It should also be remembered that AI, even though a potent force multiplier can only provide ‘part of the solution’ and ‘not the entire solution’. This technology can be a ‘collaborators of humans’ and not replace ‘humans’ *per se*.

To conclude, AI-enabled technology applications are evolving rapidly with major implications for economies and societies and Armed Forces are no exception. Furthermore, as the fastest growing economy with second largest population coupled with a most favorable demography, our country has a significant stake in the AI revolution. With geo-economics driving geo-strategies, it needs no reiteration that a transformational thinking within the Armed Forces has to be pursued vigorously in order to remain relevant in the information and AI-led future warfare scenarios. Asset categorization of applicability of AI technologies would be of critical importance. A determined and synergistic effort, with all the stakeholders on board with due impetus from the National apex level will yield dividends.

Undoubtedly, AI stands out as a transformational technology in today’s digital age. Many experts fear that the pace of AI technology development is moving faster



than the speed of policy implementation. Therefore, we need to adopt an incremental and integrated approach to harness the enabling tool in a manner to exploit capabilities of humans and machines to outperform our adversaries. With the rapidly changing character of war, it is evident that if we ignore developing AI technology today, it will be at the peril of being unsuccessful in the war of the future. Adequate resources, both human and financial resources need to be allocated on high priority in a Joint environment by the Indian Armed Forces to meet this challenge.



Acronyms

AGI	Artificial General Intelligence
AI	Artificial Intelligence
ANI	Artificial Narrow Intelligence
ASI	Artificial Superintelligence
CNDA	Confidentially and Non-Disclosure Agreements
DL	Deep Learning
DAIC	Defence Artificial Intelligence Council
DAIPA	Defence Artificial Intelligence Project Agency
DCN	Defence Communication Network
DIAT	Defence Institute of Advanced Technology
DRDO	Defence Research and Development Organization
DPP 2016	Defence Procurement Procedure 2016
DDP	Department of Defence Production
EW	Electronic Warfare
GSQR	General Staff Qualitative Requirement
GoI	Government of India
HQ IDS	Head Quarter Integrated Defence Staff
HR	Human Resource
IDU	Indian Defence University
ICT	Information and Communication Technology
IT	Information Technology
IPR	Intellectual Property Rights
IoT	Internet of Things
JSQRs	Joint Service Qualitative Requirements
LAWS	Lethal Autonomous Weapon System



LTIPP	Long Term Integrated Perspective Plan
LTPP	Long Term Perspective Plan
ML	Machine Learning
MSMEs	Micro Small and Medium Enterprises
MoD	Ministry of Defence
OODA	Observe, Orient, Decide, Act
PBOR	Personnel Below Officer Rank
QRs	Qualitative Requirements
RM	Raksha Mantri
R&D	Research and Development
RMA	Revolution of Military Affairs
RGP	Robotic Ground Platform
RSS	Robotic Surgical System
SAIL	Stanford Artificial Intelligence Laboratory
SHQ	Service Head Quarter
TDF	Technology Development Fund
UAV	Unmanned Aerial Vehicle
VUCA	Volatility, Uncertainty, Complexity and Ambiguity



Glossary³⁴

Algorithms. A set of rules or instructions given to an AI, neural network or other machines to help it learn on its own; classification, clustering, recommendation and regression are four of the most popular types.

Artificial Neural Network (ANN). A learning model created to act like a human brain that solves tasks that are too difficult for traditional computer systems to solve.

Autonomic Computing. A system's capacity for adaptive self-management of its own resources for high-level computing functions without user input.

Big Data Analytics. It is complex process of examining large and varied data sets – or big data – to uncover information including hiding patterns and unknown correlations, which can help in making informed decisions.

Data. It is the information that has been translated into a form that is efficient for processing. It can also be called as the quantities, characters or symbols on which computer operations are performed, it may be stored and transmitted in the form of electrical or electronic signals.

³⁴ Joint Services Glossary of Military Terms, 2019 Edition.



Database. Computerised information organised to make its storage, updating and retrieval efficient and reliable.

Data Ecosystem. Is a collection of infrastructure, analytics and applications used to capture and analyse data. Data Ecosystem provides organizations with data that they can rely on to understand their requirements and take sound decisions.

Database Management System. It consists of software programmes intended to provide a facility to store, update, and retrieve large information/data by a number of users simultaneously.

Data Mining. The examination of data sets to discover and mine patterns from that data that can be of further use.

Deep Learning. The ability of machines to autonomously mimic human thought patterns through ANN composed of cascading layers of information.

Defensive Capabilities. Defensive capabilities entail an operation, which can protect damage to our assets/ war waging capability, eg, Defensive Cyber Operations, Automatic Robots for border management, surveillance capabilities, etc.

Digital Innovation. It means making rapid changes by using digital technology to enhance services, traditional models, products and processes.



Facial Recognition. It is a biometric software application capable of uniquely identifying or verifying a person by comparing and analysing patterns based on person's facial contours.

Internet of Things. Interconnection via the internet of computing devices embedded in everyday objects, enabling them to transmit and receive data.

Language Translation. Translation between any two languages by use of neural machine translation.

Machine Intelligence. An umbrella term that encompasses machine learning, deep learning and classical learning algorithms.

Machine Learning. Machine learning is a capacity of a machine, which enables it to detect, classify and analyse data based on the inputs it receives, past and present. It involves creation of supervised and unsupervised algorithms in a computer programme to detect and predict.

Natural Language Processing (NLP). The ability of a program to recognize human communication as it is meant to be understood.

Network Centric Operations. Network Centric Operations is data linking of widely dispersed sensors available within a force(s) develop an integrated battle space awareness.



Offensive Capabilities. Offensive capabilities entail an operation, which can inflict a damage to the enemy's assets/ war waging capability, eg, Killer Robots, Offensive Cyber Operations, Armed UAVs, etc.

Robotics. Robotics is an inter-disciplinary branch of engineering and science that includes mechanical engineering, electronic engineering, information engineering, computer science and other fields. It deals with design, construction, operation and use of robots and computer systems for their control.

Speech Recognition. Methodology and technology that enables the recognition and translation of spoken language onto text by a computer.