GATEWAY HOUSE
INDIAN COUNCIL ON GLOBAL RELATIONS

AI & Machine Learning for the Indian Navy

by **Cdr Amrut Godbole,** Indian Navy Fellow

PAPER NO. 21 | APRIL 2020

AI & MACHINE LEARNING FOR THE INDIAN NAVY

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Fellow, Indian Navy Studies Programme

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Cdr Amrut Godbole, a senior serving naval officer, is currently Gateway House Fellow, Indian Navy Studies Programme. A mechanical engineer by profession for the last 20 years, he has served on a variety of war ships as Engineer Officer, looking after the operation and maintenance of propulsion (gas turbine engines), power generation and auxiliary systems. Six years into his naval career, Cdr Godbole did his master's in marine engineering from the Indian Institute of Technology, Bombay (2008). He was soon after appointed to the Navy's premier technical training institute, INS Shivaji, Lonavla, as senior instructor of the gas turbine division where he guided the project for the development of controllers for gas turbine generators. He was also associated with the operational audit of warships and the training of their staff at the Sea Training Division, Mumbai. He has also been Manager (Quality Assurance) at the Gas Turbine Repair and Overhaul Facility of the Navy in Visakhapatnam. He is an alumnus of the Naval College of Engineering, INS Shivaji, Lonavla. His areas of interest include: technology absorption and adaptation techniques, disruptive technology, and geopolitics.

List of Abbreviations

3D	*Three-Dimensional*
AFSAC	*Armed Forces Secure Access Card*
AI	*Artificial Intelligence*
ARP	*Annual Review Programme*
AEC	*Atomic Energy Commission*
AR	*Augmented Reality*
AFRS	*Automated Facial Recognition System*
FY	*Financial Year*
CBSE	*Central Board of Secondary Education*
CDS	*Chief of Defence Staff*
CCTV	*Closed Circuit Television*
CAG	*Comptroller and Auditor General*
DAIC	*Defence Artificial Intelligence Council*
DAIPA	*Defence Artificial Intelligence Project Agency*
DPM	*Defence Procurement Manual*
DRDO	*Defence Research and Development Organisation*
DMA	*Department of Military Affairs*
ECG	*Electro Cardiogram*
GPs	*General Practitioners*
GoI	*Government of India*
GDP	*Gross Domestic Production*
IAF	*Indian Air Force*
IAI	*Israel Aerospace Industries*
ICT	*Information and Communication Technology*
IISc	*Indian Institute of Science*
IISER	*Indian Institutes of Science Education and Research*
IIT	*Indian Institute of Technology*
IN	*Indian Navy*
IIIT	*Indraprastha Institute of Information Technology*
IIoT	*Industrial Internet of Things*
IoT	*Internet of Things*
IPMS	*Integrated Platform Management System*
ISRO	*Indian Space Research Organisation*
ISR	*Intelligence-Surveillance-Reconnaissance*
JEDI	*Joint Enterprise Defence Infrastructure*
ML	*Machine Learning*
MoD	*Ministry of Defence*
MRI	*Magnetic Resonance Imaging*
M Tech	*Master of Technology*
MR	*Mixed Reality*
NCRB	*National Crime Records Bureau*
NIT	*National Institute of Technology*
OEM	*Original Equipment Manufacturers*
PMO	*Prime Minister's Office*
RM	*Raksha Mantri*
R&D	*Research and Development*
SAP	*Systems, Applications, Products*
SOP	*Standard Operating Procedure*
VED	*Vital Essential Desirable*
VR	*Virtual Reality*
XR	*Extended Reality*

Executive Summary

The Indian Navy is a technology-savvy force. The new-generation platforms that it operates are equipped with cutting-edge technology. This puts it in an advantageous position to develop and absorb new AI technologies that are becoming increasingly popular with the military and industry.

The Government of India has already taken concrete steps in this direction. In 2018, having identified the potential impact of Artificial Intelligence (AI)/ Machine Learning (ML) across sectors, it entrusted NITI Aayog and the Ministry of Defence with the task of establishing a roadmap for devising a national programme, aimed at research and development (R&D) of AI applications in the social sector and armed forces respectively. Consequently, in June 2018, NITI Aayog published a white paper, titled National Strategy for AI, while the task force, set up by the Ministry of Defence, called Strategic Implementation of AI for National Security and Defence, submitted its recommendations.

The task force identified Use Cases that are of strategic value, but involve prolonged R&D cycles. The long-term goals of the Indian Navy of transforming to a 200-ship force by 2027 and its continued impetus to maintain optimal combat capability, are repeatedly put to test by diminishing capital availability and shortages in manpower. It is therefore imperative that the armed forces, and more so, the Indian Navy, look to leverage the benefits of AI/ML-based technologies for improving organisational efficiencies at various levels.

This paper focuses on four additional Use Cases, viz., Inventory Management, Training, Prescriptive Maintenance, and Security & Surveillance, for implementation in the Indian Navy. The additional Use Cases identified are based on established industry capability and thus have shorter R&D cycles. These solutions, once demonstrated, can easily be scaled up to the other two forces. Industry participation in aiding skill development and delivery of Proof of Concept will be critical for the emergence of commercially viable and sustainable technologies.

A cohesive tri-services approach will be necessary to maintain inter-operability and optimal utilisation of scarce resources in developing scalable AI/ML solutions. The Department of Military Affairs (DMA), headed by the Chief of Defence Staff (CDS), can initiate the development of a common tri-services strategy and interoperable infrastructure. The inclusion of the CDS and suitable representatives from the DMA in the Defence AI Council (DAIC) and the Defence AI Project Agency (DAIPA) respectively will contribute significantly to framing a synergistic approach to the absorption of AI-based technologies.

AI Use Cases identified in this paper have commercial applications too. The development of these AI technologies in collaboration with industry and academia will help reverse the current trend in industry circles of first developing technology for commercial use and then suitably modifying it for military applications.

1. Introduction

Of all the technologies that drive digital transformation today, Artificial Intelligence (AI) is perhaps the most disruptive. Organisations failing to identify and accept AI-enabled changes will find it increasingly difficult to remain relevant. Robert O. Work, a former U.S. deputy secretary of defence, in March 2018, equated the impact of AI-based disruption in the U.S. as its "Sputnik Moment"[1].

India too is having a parallel "Sputnik Moment" with regard to AI, especially in the defence sector. In 2018, the Ministry of Defence constituted a task force, Strategic Implementation of A*I for National Security and Defence*[2], to study the future of AI in defence and identify workable AI-based solutions, called Use Cases. The Use Cases identified by the task force will undergo extended R&D cycle before their acceptance in service.

The task force's focus on Use Cases with strategic value include: Lethal Autonomous Weapon Systems (LAWS), unmanned surveillance, simulated war games and training, cybersecurity, aerospace security, and intelligence & reconnaissance.

Beyond the strategic category, however, are AI Use Cases which are equally critical to defence operations in areas such as, raising efficiencies, human resource management, and training. This paper focuses on these additional AI Use Cases for the Indian Navy. Specifically, it includes solutions for Inventory Management, Training, Prescriptive Maintenance and Security/Surveillance. These not only have shorter R&D cycles, but will also enable the Indian Navy to substantially improve operational efficiency and reduce revenue expenditure.

Once implemented, the Indian Navy will emerge as a flag-bearer for the-AI based transformation envisaged for the defence sector, and also be a model for defence-private partnerships for technology development.

2. Aligning Ambition with AI

The Army, as the largest of the three forces, has a prominent share in the defence budget, followed by the Indian Air Force (IAF) and Indian Navy. The major share of India's defence budget has always been salaries and pensions of personnel. As a result, capital expenditure for acquisitions and upgrades as a percentage of the total budget has declined from a high of 42% in Financial Year (FY) 2011-2012 to 34% in 2019-2020.

Figure 1: Average Defence Outlay 2010-2019

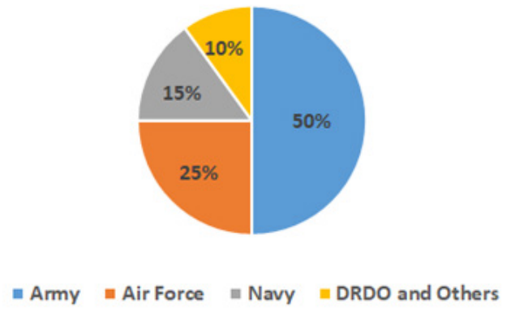
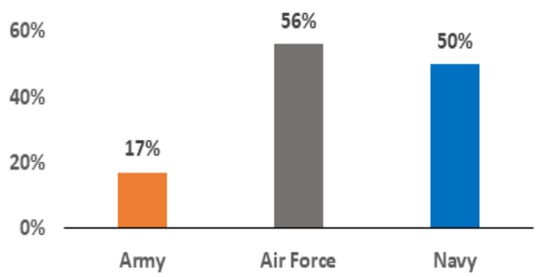


Figure 2: Capital Expenditure FY 2018-2019



Source: Gateway House Research

However, in capital expenditure terms, the IAF and Indian Navy have a larger share than the Army[3] due to the nature of their assets. Both forces must, therefore, be judicious in their expenses and resource utilisation, for which incorporating AI into their operations is necessary.

The Navy, in particular, has two goals: first, to expand its strategic footprint as a Blue Water Navy, and second, to accelerate its transformation from a "Buyers' Navy to a Builders' Navy"[4].These goals are being pursued even with a limited budget: the Indian Navy has seen unprecedented expansion in assets through prudent financial management and is upgrading itself from a force of about 130 combatant platforms (ships and submarines) to a 200-ship force by 2027[5].

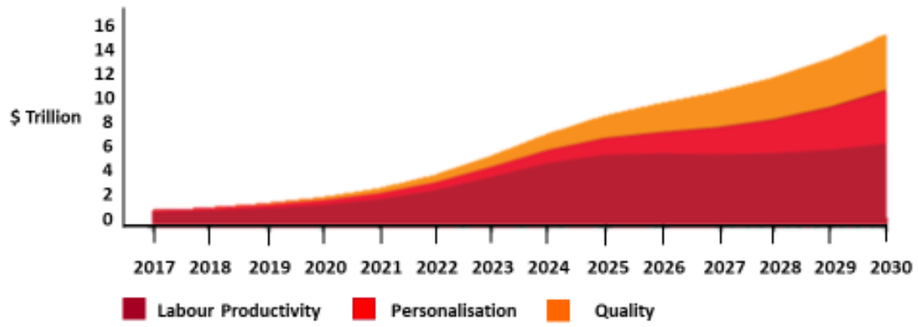
Capital availability for this exercise is dependent on the Indian economy's performance, which, in turn, is now increasingly coupled with the global economy's. The Indian Navy is deficient in both platforms and manpower. In December 2018, the Indian Navy had a shortage of more than 1,500 officers[6] and 16,000 sailors[7]. An organisational restructuring was begun that year to address the problem through the "lean manning" of platforms.[8] This is in line with the advanced navies of the world where the operator of any system is also technically qualified for the first line of maintenance of that system.

Capital and manpower shortage are the two challenges which a growing naval force will have to navigate in pursuit of its goal for 2027. AI offers solutions to address both simultaneously.

2.1 Current Global Trends

Artificial Intelligence is the main driver of Industrial Revolution 4.0[9] and is estimated to add $15.7 trillion to the global economy by 2030[10]. In particular, AI-based improvements in labour productivity are estimated to contribute over 55% of global growth by 2030.

Figure 3: Global GDP Impact of AI



Source: PwC Report of 2017 Sizing the prize - What's the real value of AI for your business and how can you capitalise?

The top positions in the Government AI Readiness Index 2019 report, compiled by Oxford Insights[11], are claimed by Singapore, UK, Germany and the U.S., with India placed at 17 among the 194 governments of countries assessed for AI-readiness (China is at 20).

The current growth in AI transformation has been led by civilian enterprise globally, primarily driven by four sectors: automotive, financial systems, retail healthcare, and manufacturing. The defence sector has now begun to pay attention after seeing the success of civilian applications and understanding AI's potential in the military arena.

The development of AI for defence is focused on combat training, intelligence-surveillance-reconnaissance (ISR), computer vision software, autonomous weapon systems, military robots, cybersecurity, security, and surveillance. The Use Cases therefore, identified by the Ministry of Defence task force, are in alignment with global trends.

2.2 India on the AI Track

In February 2018, NITI Aayog was entrusted with the task of establishing a roadmap for developing a national programme, aimed at research and development of AI applications[12]. By June that year, NITI Aayog had published a discussion paper, called *National Strategy for AI*[13], which laid down the structure for harnessing transformative technologies in AI in the social sector. It identified three areas – health, agriculture, education – as the principal beneficiaries of AI technology.

A month prior, however, the Ministry of Defence (MoD) had already constituted a task force to study the Strategic Implementation of AI for National Security and Defence. It was headed by Tata Sons Chairman, N. Chandrasekharan. The other 16 members in the task force included: the National Cyber Security coordinator, chairman and managing director of Bharat Electronics Ltd., and representatives from the Army, Navy, Air Force, Indian Space Research Organisation (ISRO), Atomic Energy Commission (AEC), Indian Institute of Science, Bangalore, IIT (Bombay), IIT (Madras), and private industry.

The task force submitted its report to the Raksha Mantri on 30 June 2018[14]. The five Use Cases it identified are as follows:

Figure 4: AI Use Cases identified by Task Force

Source: Gateway House Research

Based on the recommendations of the task force, the ministry's Department of Defence Production (DPP) issued a Government Order, dated 8 February 2019[15], for an operating framework, policy-level changes, and the structural support required for AI-based transformation in the defence sector. An annual sum of Rs 100 crores has been earmarked from the budgetary allocations of each of the three services for the next five years.

The Defence AI Council (DAIC), headed by the Raksha Mantri, is mandated to develop an operating framework, recommend policy-level changes, and facilitate structural support for the implementation of AI as a common tri-services strategy. The implementing agency for the DAIC is the Defence AI Project Agency (DAIPA), headed by the Secretary (Defence Production), which will evolve and adopt standards for technology development and the delivery of AI projects.

3. Additional Use Cases for the Indian Navy

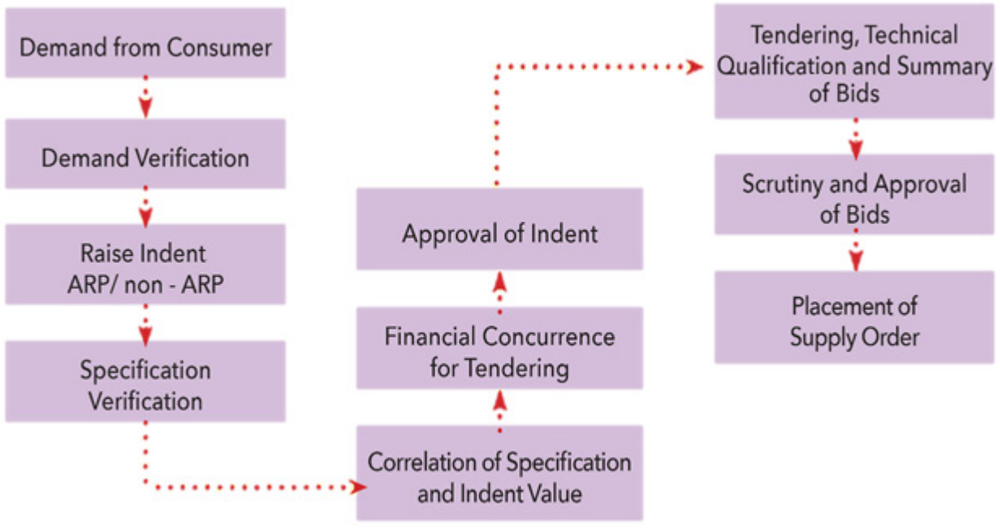
The Use Cases, already identified for military application by the task force, have immense strategic value and will improve combat capability. But they are R&D-intensive and will have to undergo prolonged R&D cycles prior to becoming viable. In the meanwhile, there is value in developing additional Use Cases that will have a positive and immediate impact on operational efficiencies, human resource management, and training. These are:

- Inventory management
- Training
- Prescriptive maintenance
- Security/surveillance

3.1 Use Case 1 - Inventory Management

Efficient inventory management anywhere means keeping enough stock in the warehouse to ensure that organisational needs are met, but not overstocking, thereby draining limited cash reserves. This dilemma is at the heart of every inventory manager's professional responsibilities. The Indian Navy currently operates a Systems Applications and Products (SAP)-based platform for inventory management which is similar to that used traditionally in industry. A typical procurement cycle, followed by the Indian Navy, is depicted below.

Figure 5: Procurement Cycle



Source: Gateway House Research

As per the Defence Procurement Manual (DPM)[16], the time prescribed for procurement under the single and two-bid systems, from vetting of the indent to placement of supply order is 19-23 weeks. These timelines are often difficult to adhere to because of multiple intrinsic issues, such as those identified by the Comptroller and Auditor General of India (CAG) in Report 20 of 2017[17].

- ineffectiveness of the existing automated Annual Review Programmes (ARP) to forecast procurement needs;
- incorrect categorisation of items into VED (Vital, Essential, Desirable)/ABC;
- pressures from the end-user;
- vendor management;
- obsolete inventory held in stock;
- high ratio of non-moving inventory occupying valuable storage space;
- serviceable surplus spares;
- managing limited life inventory; and
- stock verification.

These issues have a cascading effect on procurement timelines, mainly through delays in indent approvals and placement of supply orders. The existing SAP-based platform is still heavily reliant on manual intervention.

The lack of predictability of equipment performance based on data analytics and an over-reliance on Original Equipment Manufacturers (OEMs) for preventive maintenance have had a severe impact on inventory forecasting and management. This has led to expensive inventory lying unused.

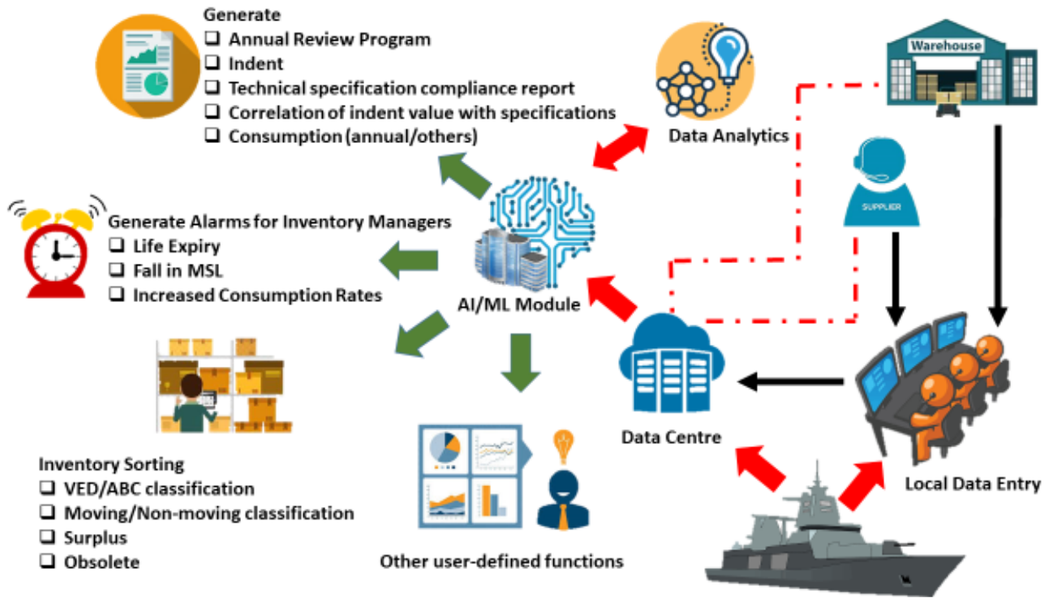
Historically, the Indian Navy was dependent on the erstwhile Soviet Union for warship production and maintenance inventory. Its fall led to the Navy sourcing equipment and platforms from other countries. Additionally, it developed a stated vision to support indigenisation[18]. The result has been an enormous build-up of inventory from multiple OEMs/suppliers.

This requires urgent change. The remarkable advances made by the e-commerce/logistics industry across various sectors, on the back of AI/ML based models will be also useful for inventory management in the Indian Navy. The network-based logistics industry, driven by software-based platforms, provides a natural framework for integrating AI solutions.

An AI-based system will be a natural transition from the existing one, which is already rich with data.

A basic architecture of such a system is shown below:

Figure 6: Basic Architecture of AI/ML-based Inventory Management System



Source: Gateway House Research

The success of any AI system, based on ML, is built on algorithms and quality data. The database of the existing inventory management system is vast, but needs microscopic authentication before it can become the backbone of any new AI/ML system. The new system should include features, such as automated inventory monitoring, supply chain management (from supplier to material depot to consumer), just-in-time supply of non-critical and limited life components/items, financial anomaly detection, predictive logistics, quality inspection and, most importantly, customer feedback.

Implementing an AI/ML-based inventory management system will:

- reduce dependence on human intelligence for data analytics;
- reduce the workload of inventory managers;
- establish intelligent consumption patterns;
- efficiently manage warehouse space;
- accelerate the response to consumer demand; and
- generate reports and alarms for inventory managers.

3.2 Use Case 2 – Training

The foundation for success in combat is training. In turn, the efficacy and productivity of the Indian naval training organisation has a direct bearing on combat-readiness and the operational effectiveness of naval platforms/ systems.

Three challenges exist:

One, operators and maintenance personnel on board warships are constantly tested by the rapid progress in technology across weapons, sensors, propulsion, communication, electronic warfare systems, etc. Training those who handle such advanced technologies is, therefore, an on-going process, calling for continuous learning.

Two, the lack of experienced instructors to cater to the needs of an expanding Navy impedes effective training. To bridge this gap, the tendency is to draw personnel already deployed on ships and other support organisations, which, in turn, affects productivity and results in ineffective training outcomes while having an impact on operational balance across the service.

Three, deputation of naval personnel as trainees and trainers to the Indian Navy's training centres spread across the country constitutes a mammoth logistical exercise and expense.

A 2018 CAG report on the state of the defence services brought out various deficiencies in training[19]. It built on CAG Report 20 of 2017, which stated that an overwhelming 71% of accidents are attributable to crew error or non-compliance with Standard Operating Procedures, or simply, organisational failure. It is, therefore, imperative for the Indian Navy to develop newer models for training personnel, based on AI/ML.

Training in any organisation comprises three main components: the end users (learners), the training function (teacher), and training management. Each category has its own unique training imperatives, but the common goal is satisfying organisational skill requirements. Here, an AI/ML-augmented training system will substantially improve the targeted deliverables of the traditional training cycle. Several innovative products are available in the market. The success of education platforms like Byju's[20] serves as a good model for large-scale and diverse training needs. Some of the technologies that can transform training in the Indian Navy include Virtual, Augmented and Mixed Reality, all collectively called Extended Reality (XR).

XR consists of real-and-virtual environments, generated by computer graphics and wearables. The Augmented Reality (AR)/Virtual Reality (VR) market, already worth $7.9 billion in 2018, is estimated to reach $44.7 billion by 2024[21].

Virtual Reality

VR intends to replace users' existing reality (environment) with a virtual one. VR technology can provide on-demand training portability to the edge, on board ships and shore facilities.

Figure 7: Virtual Reality

Source: https://www.turbomachinerymag.com/virtual-and-augmented-reality/

Augmented Reality

Augmented Reality or AR intends to superimpose digital/virtual reality on the existing reality (environment). It delivers virtual elements as an overlay to the real world. Such applications will be helpful, especially in the training of personnel who handle repairs of engines, pumps, systems, etc. AR can also be used for enhancing safety and procedural awareness of crew on board. Such systems significantly improve performance by reducing errors and increasing efficiency.

Figure 8: Augmented Reality

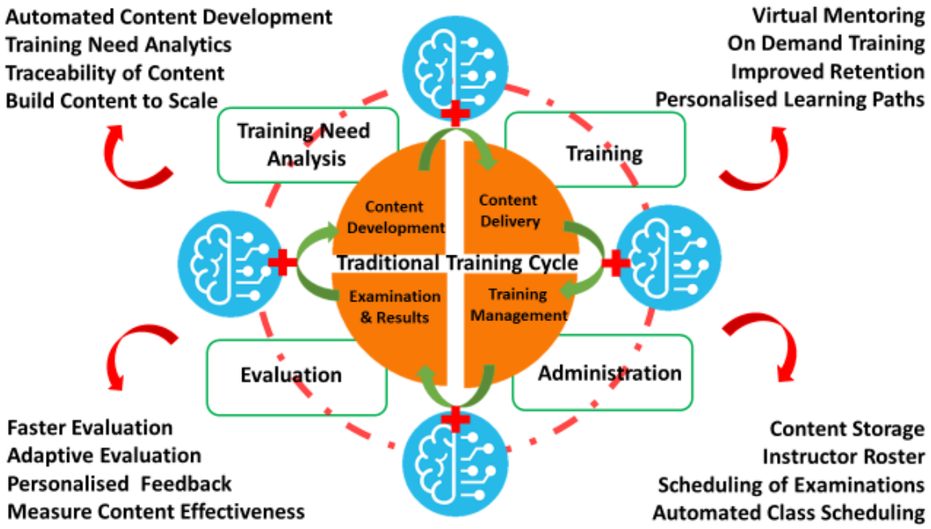
Source: https://pluto-men.com/insights/power-your-people-with-augmented-reality-based-remote-assistance/

Mixed Reality

Mixed Reality (MR) refers to the combination of virtual environments and real environments by using a combination of both AR and VR technology. Such technology uses depth and spatial sensors to anchor interactive 3D digital elements into a user's environment, making it easier for him or her to navigate around virtual objects. MR requires advanced sensors for spatial awareness and gesture recognition, useful in combat, damage control, and fire-fighting training.

To use the AI/ML-based system, the Indian Navy needs to know which training needs are open-source and which require a higher security classification. Most technical and tactical training can be open-source, requiring lower-security exchange protocols; the balance can be structured around a higher-security exchange network. The Indian Navy needs to augment the existing Navy Digital Network's [22] bandwidth and security to permit users to access training on demand. A basic architecture of the AI/ML-assisted training model, and the advantages one can expect, is given below.

Figure 7: Virtual Reality



Source: https://www.turbomachinerymag.com/virtual-and-augmented-reality/

Implementing the AI/ML-assisted training model will:

- free the instructors of routine administrative tasks, such as content creation, setting tests and evaluation, so that they can focus on necessary research-based activities, which is the core purpose of an educational institution;
- enable delivery of adaptable and on-demand content;
- significantly improve demonstrated skills at the edge; and
- facilitate remodelling of training need analysis, based on automated data.

3.3 Use Case 3 – Prescriptive Maintenance

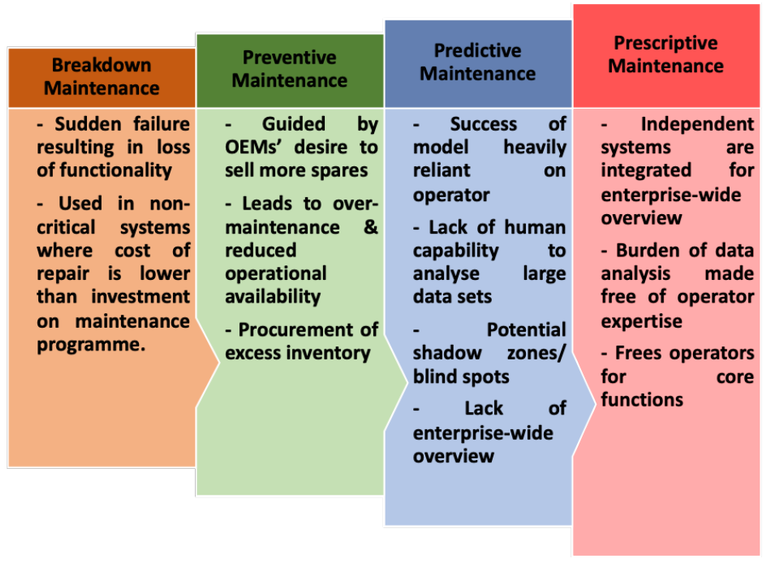
Maintaining the reliability of any equipment or system so that it can provide repetitive design performance is a central objective of platform or facility managers in the Indian Navy. Unexpected failures directly hit productivity, operational efficiency, and combat-readiness. Their foremost concern is to ensure that all assets remain healthy, on-line, and productive. Their maintenance philosophy has so far relied on the frequent monitoring of every eligible machine or component in a platform or facility, a task becoming increasingly impossible as the Indian Navy has had a technological surge overtake its platforms in the last few decades.

Modern online 'condition monitoring technologies' for highly critical turbomachinery assets have been deployed in the Indian Navy, but auxiliary equipment-wide assets continue to be checked via a periodic walk-around, which is economical, but infrequent. In both cases, the burden of analysing thousands of interdependent parameters and providing an accurate and coherent prediction of the performance of the equipment and its impact across the platform or facility, are still heavily reliant on the skill of the operator or maintainer.

The shortage of skilled manpower and the frequent transfer cycle leaves a wide gap in institutional memory. AI/ML-based prescriptive maintenance systems can overcome this by shifting the onus of prediction and expertise from the human to the asset or equipment.

The Navy's intent to transit from a preventive maintenance, to one based on a condition, has met multiple challenges. In practice, due to the absence of a robust predictive maintenance programme, the Indian Navy still undertakes a significant number of planned, preventive maintenance activities.

Figure 10: Transition of Maintenance Philosophy



Source: Gateway House Research

Equipment performance deterioration, if not predicted, will lead to an increased scope of work during the planned maintenance windows. This can be limited through minor maintenance corrections during the operational cycle. The Integrated Platform Management System (IPMS) on board new-generation ships in the Indian Navy, already equipped with the necessary sensors, will serve as the backbone for an AI/ML-based predictive maintenance model.

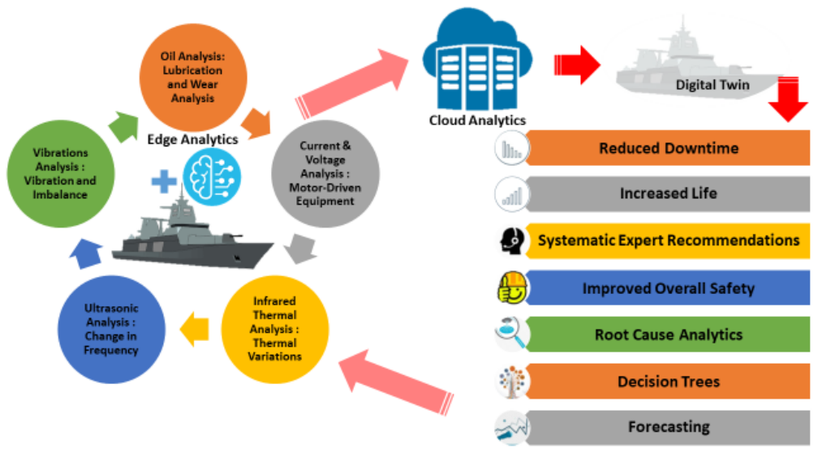
The implementation of an AI/ML-based, single-enterprise solution, capable of monitoring the health of critical and auxiliary machinery, will substantially reduce the perpetual fatigue of operators and maintenance staff, while improving the operational availability of platforms and productivity in support facilities.

Any AI/ML-based model is data-hungry. The accuracy of the model largely depends on the quality and quantity of data that drives the analytics. Data localisation and data transfer lag are two important factors that must be considered while building the architecture. The availability of space, especially on-board a warship, is at a premium. It will, therefore, be prudent to consider a hybrid model for data storage and analytics. This will consist of limited edge (on-board ship), but extensive cloud (shore-based) analytic capabilities.

The edge analytics component will provide prescriptive and corrective insights, restricted to operator or maintainer-sensitive operations. These insights will be real-time, but will have prediction capabilities limited to operator response.

The cloud analytics, on the other hand, will be capable of generating superior analysis, insights and prediction response (all combined as prescriptive analytics), on equipment performance. This is crucial for the optimal planning of maintenance periods. Cloud analytics will significantly improve the capabilities of shore-based trial teams for comparing equipment performance across various platforms and provide timely insights to operations and maintenance managers. Cloud-based analytics can be subsequently used to develop digital twins of critical machinery/systems[23]. Once in place, this will obviate the requirement for ships to proceed to sea, specifically for machinery performance checks.

Figure 11: AI/ML-Based Prescriptive Maintenance Capabilities



Source: Gateway House Research

Shore-based organisations operating capital-intensive machinery and equipment too should be integrated into cloud analytics. For this, they will need to undergo a sensorisation drive to upgrade legacy equipment capabilities. Smart sensors are increasingly a popular option for industries across the world as the first step to switching over to prescriptive maintenance. Over the past decade, the cost of such sensors has declined by about 100 times, while the number of sensors, shipped globally, increased from 4.2 billion units in 2012 to 23.6 billion units in 2014[24]. This is set to rise to 50 billion units by 2020[25].

Sensor technology is increasing in sophistication such that wearable alert devices will detect and identify a variation in the noise of an individual piece of equipment in a cluster and correlate it to an off-design operation.

Table 1 – Smart Sensors for Predictive Maintenance

FEATURE	FUNCTIONALITY	APPLICATION
For Motors	**Health Parameters** • Overall condition • Overall vibration (velocity RMS) • Bearing condition • Misalignment • Temperature (degrees) **Operating Parameters** • Radial vibration (velocity RMS) • Tangential vibration (velocity RMS) • Axial vibration (velocity RMS) • Speed (RPM) • Operating hours • Number of starts • Supply frequency (Hz) • Output power (hp/kW) • Re-greasing count-down • Current, voltage	• Easy installation • Reduced downtime up to 70% • Improved energy efficiency up to 10% • Extended motor life up to 30% • Easy connectivity with Industrial Internet of Things (IIoT)
For Pumps	**Health Parameters** • Overall condition • Overall vibration (velocity RMS) • Bearing condition • Misalignment • Unbalance • Looseness • Blade problems • Temperature (degrees) **Operating Parameters** • Radial vibration (velocity RMS) • Tangential vibration (velocity RMS) • Axial vibration (velocity RMS) • Speed (RPM) • Operating hours • Number of starts	• Easy installation • Easy identification of pump inefficiency • Prevention of unexpected downtime • Reduced maintenance costs • Extended equipment life • Better safety and reliability • Easy connectivity with IIoT

Table 1 – Smart Sensors for Predictive Maintenance

FEATURE	FUNCTIONALITY	APPLICATION
For Anti-Friction Bearings	• Vibration • Temperature (degrees)	• Easy installation • Increased safety • Increased productivity • Reduced maintenance • Eliminated unplanned stops • Easy connectivity with IIoT

Source: https://new.abb.com/future/smartsensor

Implementing an AI/ML-assisted predictive maintenance model will:

- free the operator/maintainer from physical parameter analysis and performance prediction;
- provide online interjections to off-design performance, reducing the risk of major failure or increased scope of work during scheduled maintenance layoffs;
- reduce downtime and increase reliability of equipment;
- improve efficiencies in the life cycle management of platforms;
- provide data analytics-backed root-cause analysis of defects; and
- improve operational safety.

3.4 Use Case 4 – Security and Surveillance

Traditionally, security and surveillance in the armed forces has been physical, both in terms of infrastructure (perimeter walls, barricades, hydraulic bollards, tyre killer, etc.) and human presence. Faced with unprecedented changes in the security environment and in light of manpower deficiencies, the Indian Navy adopted a multi-pronged approach to address this problem. Solutions included the outsourcing of security and surveillance internally at vital positions, and to external agencies at non-vital locations. This approach, however, further accentuated the manpower shortages internally and also incurred greater costs.

All installations under the defence services have to continuously ensure their security through strict access control and continuous surveillance. Access-control checks, which are currently physical, are being augmented through the Armed Forces Secure Access Card (AFSAC) Project[26]. Surveillance has added Closed Circuit Television (CCTV) systems at vital locations. These measures will aid in improving the security environment, while retaining the onus of data analytics on the human. This results in intermittent analytics, subject to human efficiency, and a delayed response to a possible security breach.

An AI/ML-based security and surveillance system will typically consist of hardware, such as trip wires, cameras, radars, drones (aerial and underwater), etc., and software for machine learning and data analytics.

Trip Wires

Trip wires can be integrated into AI/ML-based security and surveillance systems to set off an alarm on being stimulated. These can be used for perimeter security applications.

AI-Based Cameras

AI-based cameras will revolutionise security and surveillance systems. Some of their features are detailed below:

Table 2 – Features of AI-based Security/Surveillance System

FEATURE	FUNCTIONALITY	APPLICATION
Facial Recognition	AI-enabled cameras recognise the face of a registered person. Should an unregistered person enter the covered area, an alert is generated.	Access control
Voice Recognition	Advanced security cameras include voice recognition features, which are used for access control, along with the facial recognition feature for access control of highly sensitive installations.	Access control
People Count	Allows an organisation to keep track of people entering and leaving a restricted area.	Access control
Number Plate Recognition	Reads the number plate of any vehicle in the covered area within a speed range of 0-200 km/hr.	Access control
Intrusion	Creates an alert when an unauthorised person tries to cross a designated area.	Perimeter surveillance
Moving Object Detection	AI-enabled cameras can differentiate the physical features of a human being from that of an animal, and generate alerts.	Perimeter surveillance
Moving Object Detection	A notification will be generated if anything goes missing from the camera's view.	Infrastructure-wide surveillance
Abandoned Object	A notification will be generated if an object is left beyond a defined time period in the normal view of a camera.	Infrastructure-wide surveillance
Gesture Control	Enables cameras to understand a person's pre-defined gestures and automatically respond by zooming the lens, tracking footsteps, taking an image etc.	Infrastructure-wide surveillance
Heat Map	Infrared feature used to locate hot spots and major temperature variations in the areas under surveillance and generate a heat map which is notified to users.	Fire and anomaly detection
Smoke Detection	A notification will be sent on detection of smoke.	Server rooms, fire risk areas

Source: https://new.abb.com/future/smartsensor

The National Crime Records Bureau (NCRB) under the Government of India is already working towards creating an Automated Facial Recognition System (AFRS)[27] to make security forces more efficient. The Indian Navy should leverage the NCRB's experience in this and form its own security and surveillance system with applications based on facial recognition.

Radars for Perimeter Detection

The attack on the Aramco oil field in September 2019, using drones, has been a global advertisement of their use for destructive purposes. Vital installations across the globe can no longer neglect such threats. Israel, one of the major players in the field of security and surveillance, provides solutions against such threats. The ELM-2114 Persistent Perimeter Detection Radar[28],developed by M/s IAI, Israel, is one such product. This is a high-resolution radar that uses advanced multi-beam technology for persistent surveillance target-tracking over an area of interest even in the toughest weather conditions. The ELM-2114 features a stationary (non-rotating) planar array that covers 90 degrees in azimuth sector and 12 degrees in elevation – which helps to detect drones. It has a detection range of up to 500 m for moving humans, and up to 1,000 m for moving vehicles.

Figure 12: ELM-2114 Persistent Perimeter Detection Radar

Source: https://www.iai.co.il

Underwater Autonomous Drones

The DRDO, in March 2018[29], announced the development of a low-endurance prototype for underwater surveillance. The successful trials of this drone system will provide a reliable alternative to ships anchored or berthed alongside for underwater surveillance. Apart from High Definition underwater cameras, the systems, so developed, should be capable of mounting various remote-controlled accessories, such as ultrasonic thickness-gauging sensors, cleaning brushes, mini cutters, grip-sticks, cathode potential probes, etc. This job is currently being done by a diver who undertakes occasional inspections. The underwater drone will provide continuous surveillance.

The Indian Navy should look at implementing a combination of the above-mentioned technologies, based on security and surveillance requirements. A common cloud-sharing platform across all the Navy's shore-based establishments will enable seamless data-sharing between organisations.

Implementation of an AI/ML-assisted security and surveillance model will :

- provide real-time and continuous security and surveillance;
- free up skilled manpower, reduces expenditure and dependencies on outsourcing;
- offer reaction time for response teams by predicting the possibility of a breach/situation through system-generated alerts and notifications; and
- improve efficiencies in a coordinated response to a security situation.

The four additional Use Cases identified can drastically improve operating efficiency at various levels and improve combat effectiveness. Additional Use Cases which the Indian Navy can also explore are in Appendix 1.

4. Challenges

Organisations failing to accept and leverage the advantages offered by AI/ML-based technologies for fear of data breach or misuse will lose combat competitiveness. The drawbacks of continuing with traditional, inefficient human-based operations far outweigh the risks posed by implementing AI/ML-based technologies across various Use Cases. The following challenges are considered stepping-stones towards creating a military which effectively leverages the power of AI/ML-based tools:

- formulation of a common AI strategy across the three defence services for greater synergy and cost effectiveness;
- setting up of standards for technology development and delivery process for AI that include an Information and Communication Technologies infrastructure (including cloud); cybersecurity; and data classification and localisation needs;
- the skilling of the work force to leverage AI/ML-based technologies; and
- reducing reliance on foreign manufacturers for hardware components through their indigenous development.

5. Recommendations

5.1 Recommendations for Government of India

Tri-Services Synergy for AI Infrastructure and Interoperability

Military applications based on AI cannot operate on open-source Information and Communication Technology (ICT) networks and cloud services. Indigenous development of a cloud-based interoperable infrastructure, dedicated to the three services, will be imperative for the growth of AI-based Use Cases within the armed forces.

In October 2019, the U.S. Department of Defence awarded a $10-billion contract to Microsoft for developing the Joint Enterprise Defence Infrastructure (JEDI).[30] This was a response to China establishing the Joint Laboratory of Intelligent Command and Control Technology[31] in January 2018 under China's 13th five-year plan – a Special Plan for Military-Civilian Integration Development (military-civil fusion)[32].

India needs to do the same. With the creation of a Department of Military Affairs and appointment of a Chief of Defence Staff[33], the government has paved the way for such synergy. The mandate of the DMA includes promoting cohesion in military procurement, training, and staffing for the services through joint planning and integration of their requirements.

The CDS and members of the DMA are not a part of the Defence AI Council (DAIC) and Defence AI Project Agency (DAIPA) respectively – and must be included.

5.2 Recommendations for Indian Navy

Skilling of Work Force

The existing and newly inducted work force must absorb new AI technologies. Re-skilling the existing work force and training the new inductees is a prerequisite to building a future AI-ready force.
The June 2018 NITI Aayog paper, National Strategy for Artificial Intelligence - AI for All, primarily covers AI applications that will have maximum social impact. The recommendations made there for AI skill development are equally applicable to the Indian Navy. Leveraging the initiatives that the government will roll out in coordination with academic institutes for AI-skilling will provide a ready platform for the Indian Navy.

So far, the Indian Navy has entered into a Memorandum of Understanding (MoU) with the Indraprastha Institute of Information Technology (IIIT), Delhi, which offers naval officers an M-Tech in Artificial Intelligence[34]. However, skilling only a few officers will have limited impact and result in considerable latency in AI technology absorption and utilisation. The Indian Navy will, therefore, have to take urgent steps in re-skilling and training of the entire pyramid of manpower from the bottom up and in its training institutes.

There are several AI initiatives of the Government of India[i], which the Navy should take note of and assimilate into its own training syllabus.

Navy-Industry-Academia Synergy

India is home to world-class professionals and academicians in computer science and engineering verticals. Institutes of higher education, such as the IITs, Indian Institute of Science, National Institutes of Information Technology and the Indian Institutes of Science Education and Research (IISERs), contribute significantly to global R&D efforts in emerging technologies.
The Indian Navy has long been engaged with academia, but has not yet harnessed the capabilities of Indian industry, which has already begun using advanced data analytics and AI to transform their business processes for the Industry 4.0 era.

Industry-navy contact centres can be established at locations like Mumbai/Pune, Bengaluru and Hyderabad, which house a number of established industry players as well as start-ups working in the field of digital analytics. The Navy can develop a Proof of Concept model in each of the identified additional Use Cases as part of student projects before rolling out the system enterprise-wide. Prominent domestic players, providing AI solutions, can become partners in these projects along with designated end users. This strategy will create AI awareness in young minds and provide a platform for AI system developers and end users to assess and refine the technology to come.

Industry, through its participation at the Proof of Concept stage and subsequent development of the larger end use application, will benefit from developing a defence technology in the national interest that will also find commercial application and scalability.

A naval/defence exhibition in collaboration with the DRDO and major defence public sector units (PSUs), with a theme dedicated to AI applications for the Indian Navy, will be instrumental in attracting domestic players to gauge market interest and capability assessment.

[i] *The Government of India, having identified the disruptive impact of AI and its dependence on a skilled work force, has directed the inclusion of AI as part of the CBSE syllabus. As part of this initiative, a 12-hour 'Inspire' module on Artificial Intelligence has been announced, which schools can take up with students of Class VIII. The study material for teaching Artificial Intelligence in Classes VIII and IX has already been provided to schools through the CBSE's website. IIT Delhi has recently introduced 'Buddhi' AI Kit, aimed at providing first-hand experience in AI, facilitating learning of AI basics and building AI-based projects.*

Appendix-1 Table 3 – Additional Use Cases

USE CASE	APPLICATION	REFERENCE PLATFORMS WITH INDIAN PRESENCE
Vehicle Management System	This system will be useful to map the entire vehicle inventory owned/hired by the Navy. A common AI-based digital platform at the regional level will aid in substantially reducing the inventory as well as hiring requirements.	Azuga, Bengaluru Gobolt, Gurugram Cellocator
Medical Management System	This system will substantially reduce the burden of medical GPs/specialists in the Indian Navy in the performance of routine tasks, such as Annual Medical Examinations, reporting of MRI, ECG, haematology and multiple other reports. The availability of a person's medical history virtually at one's fingertips substantially reduces medical response time in an emergency.	Doxper, Mumbai Artivatic, Mumbai Soulpage IT Systems, Hyderabad
Logistics Management System	Different modules, such as: • documentary compliance in financial cases, personal claims; • procurement and delivery of rations along the lines of Big Basket; • procurement of clothing based on personal history; • smart ledgers.	Locus, Bengaluru Artivatic, Mumbai Persistent Systems, Pune
Remote Fire Fighting System	Autonomous systems to assist in discovery, control and damage control of incipient fires. Developing the human-robot interaction technology will allow a Navy firefighter to interact peer-to-peer, shoulder-to-shoulder with a humanoid robotic firefighter. Indigenous development of a robot on the lines of Shipboard Autonomous Firefighting Robot (SAFFiR).	Universal Robotics, Bengaluru
HR Management System	Will make the process impersonal.	Edge Networks, Bengaluru Mettl, Gurugram
Operation, Maintenance and Management System for Yards and Repair Agencies	Preventive/Predictive Maintenance, Asset Tracking, Daily Checklists, Inspection and Calibration are critical for 24x7 operations of any industry. Due to manual data management there is a high chance of operators missing out on important SOPs and tasks.	Clairviz, Mumbai Altizon, Pune QIO Technologies, Pune

Source: Gateway House Research

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