ARTIFICIAL INTELLIGENCE IN AIR OPERATIONS PLANNING PROCESS

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INTRODUCTION

It is widely believed that the world is on the brink of another military revolution. Artificial Intelligence (AI) is about to transform the characteristics and, to a certain degree, even the nature, of warfare, as aircraft, tanks, gun power and the atomic bomb did in the previous era. AI is defined as the development of computer systems able to perform tasks that normally require human intelligence, at lightning speed, such as decision-making, automated data analysis, providing solutions with options for choice, speech recognition, visual perception and translation between languages. While AI is already being used for the development of tactical war-fighting systems, more opportunities exist towards utilisation of AI in the strategic and operational planning process in air operations. It is important to harness this technology for use in the strategic and operational planning processes as well.

The question is regarding how AI can be incorporated into the air operations planning process in the Indian Air Force (IAF), with the aim to fully exploit this crucial emerging technology for enhancing operational

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capability. This will involve development of autonomous systems in areas of command and control, operations planning, air tasking, maintenance and logistics and administrative aspects. It will spell out the kind of algorithms that need to be utilised in order to achieve these stated objectives of making the air operations planning process as fully autonomous as possible.

Artificial Intelligence (AI) and Machine Learning (ML) teach computers to carry out tasks in a semi-supervised manner, utilising enormous data sets. AI in an operational environment analysis would involve AI-enabled systems for threat detection in the operational environment, threat analysis and threat resolution. AI systems have the ability to predict enemy behaviour, anticipate vulnerabilities, weather and environmental conditions, assess mission strategies and suggest mitigation plans. This saves time and human resources, and puts the combatants in the field a step ahead of the adversary.

The Air Operations Planning Process (AOPP), in a nutshell, is the process of turning the strategic plan into a detailed plan that outlines exactly what action the air force commanders will take at different levels during contingencies. Heavy processing of data is involved in the various steps of AOPP. At present, most of the processing is done manually or fed manually in specific software/tools but there is scope for reducing the workload of the planning staff in certain steps of AOPP through the integration of AI.

ARTIFICIAL INTELLIGENCE

Artificial intelligence refers to the simulation of human intelligence over complex problems with the ability to offer multiple and viable options at enormous speed by machines. It is accomplished by studying patterns of the human brain and analysing the cognitive process. Cognitive functions are mental processes involved in acquiring knowledge, manipulation of

information and reasoning. They also include areas such as perception, memory, learning, attention, decision-making and language abilities. In other words, cognitive ability or functions have more to do with mechanisms of how we learn, remember, solve a problem and pay attention, and less to do with knowledge.

One of the key advantages of using AI will be expeditious processing and analysing the enormous data to offer valuable insights and help in the decision-making process.

Before we understand the role of AI in AOPP, it will be handy if we also briefly understand what machine learning and deep learning are. It is a combination of all three, wherein machine learning is a sub-set of AI, having the ability to self-learn, based on the algorithm. It is here that the system gets smarter. Whereas deep learning is machine learning applied to large data sets, it is in here that AOPP will have multiple agents like Intelligence, Surveillance, Reconnaissance (ISR), Imagery intelligence (IMINT), Signals Intelligence (SIGINT), e-MMS, Integrated Material Management Online System (IMMOLS), Mausam, etc which will create a large data base. On this data base, which will have various hidden layers (of various agents) communicating between the multiple agents, machine learning will work on the basis of the algorithm generated by the user.

WAYS AI CAN AUGMENT AOPP

Warfare Systems: These are weapons, sensors, command and control, navigation, aviation support systems, mission planning, ISR, communications, etc. AI will play a big role in all these systems to optimise their utilisation, improve Situational Awareness (SA), help make decisions faster, and be more accurate.

Decision-Making: One of the key advantages of using AI will be expeditious processing and analysing the enormous data to offer valuable insights and help in the decision-making process.

Data Processing and Research: Here the AI will help in converting the data into more usable, and in the desired form, making it more meaningful.

Operational Environment Analysis: Satellites, Airborne Warning and Control System (AWACS), drones, etc offer vital inputs to the commander for the next Course of Action (COA). The ability of AI powered drones for exercise /drone swarms for effective target selection by communicating the distance, direction and elevation of a target will provide a real-time source of inputs for operational environment analysis:

Data Collation/Simulation, Training and Analysis.
Threat Monitoring, Target Study and SIGINT Collation.
Cyber Security.
Logistics and Casualty Evacuation.
Operation Planning, Operational Air Movement Plan (OAMP), Command and Air Tasking Order (CATO) and Route Preparation.
Operational Execution and Issue of Executive Orders (Exors).

CHALLENGES POSED BY AI

Data Quality and Reliability: This is an important aspect on which the complete prognosis depends i.e. on accurate, complete or reliable data, otherwise the results will not only be incorrect but rather catastrophic.

Cyber Security Vulnerabilities: AI systems are vulnerable to cyber attacks and would pose an extremely difficult challenge to protect them from one.

Training and Expertise: Developing a skilled workforce proficient in AI will be a mammoth challenge.

Ethical Questions: Further deliberations need to be made on whether life and death decisions can be delegated to an autonomous machine.

Bias and Fairness: Algorithms can inherit biases present in training data, which can lead to bigoted discriminatory outcomes. The same may have severe consequences.

The Question of Accountability: Introduction of AI enabled systems raises the question of accountability of actions viz. whether an AI system or its creator can be held accountable for actions taken.

Human-AI Alliance: Integration of AI in the planning process needs to be such that all agents (data of multiple fields) are effectively and optimally communicating towards the planning process and complement the air force commanders' intent without any confusion or reliance, which is going to be a diverse task.

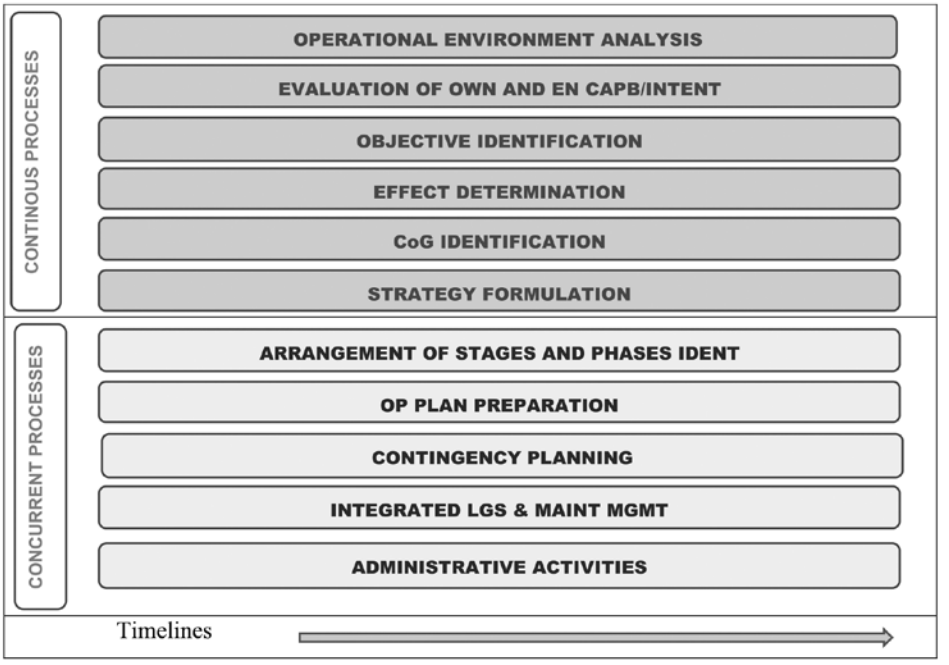
PRESENT STATUS OF AOPP

The operations planning process integrates military actions at the operational level in consonance with the national strategic objectives in a given situation. It is a sequenced, analytical planning and iterative process based on logical steps to analyse a mission and compare the available Courses of Action(COAs), select the best COA and produce a plan or an order. A successful planning process involves continuous interaction among the commander, staff and subordinate headquarters throughout the planning process. This is especially critical in the current structure characterised by central control and decentralised execution.

PROCESSES IN AOPP

AOPP involves continuous processes such as operational environment analysis, evaluation of own and enemy capabilities/ intent, objective identification, effect determination, centres of gravity identification and strategy formulation. In tandem with the abovementioned sequential processes, certain concurrent processes also take place which carry the planning process forward. Concurrent processes include the arrangement of stages and phases identification, operational planning preparation, contingency planning, integrated logistics and maintenance management and administrative activities. The diagrammatic representation of these processes is as shown below.

Fig 1



AI IN VARIOUS PROCESSES AND BROAD SCOPE

In the current AOPP model, modern computing systems have found their way into a lot of tactical war-waging platforms like radars, ISR and Surface-to-Air Guided Weapon (SAGW) systems in the IAF. The IAF's planning has evolved to adapt to different types of conflicts and threats, including counter-insurgency operations and disaster relief efforts. Overall, the history of planning airborne missions in the IAF reflects a dynamic evolution, driven by changing geopolitical landscapes, technological advancements and strategic imperatives. However, there is definite scope for the inclusion of AI in this strategic and operational planning process. This seems like the next logical and inevitable step in this direction.

HANDSHAKE BETWEEN AI AND AOPP

To broadly understand how AI will augment AOPP, it is important to understand how AI will shake hands with AOPP and at what stage.

On receipt of Ministry of Defence (MoD)/ Department of Ministry Affairs (DMA) guidelines, Air Headquarters (HQ) would initiate the first step of AOPP. This involves establishing the plan for planning or in other words, issuing broad guidelines to the concerned command headquarters. In an AI enabled operations planning process, the AI system at Air HQ would interface with input systems from other central/state agencies and sister Services. The inputs from these systems are then sent through a series of cognitive functions and modules within the AI system which include machine learning, expert systems, neural networking, computer vision, automated reasoning, deep learning and natural language processing. After completion of these complex cognitive functions, the resulting decisions, which are outputs of the AI system are then given as inputs to the output systems which encompasses orders pertaining to intelligence, deployments, launch sequences, scramble orders, etc.

A critical component of the AI system would be mission assistance computing that would provide archived data comprising orders and instructions from the higher echelons. The AI system would cross-reference this through interfaces with the existing air force doctrine, past lessons learnt and standard operating procedures. All the cross-referencing would constitute the neural network of the AI system. This system would then produce the required orders to the executing bases.

Analysis of the operational environment is then carried out after having received the orders from the higher formations. At this stage, the AI system would identify, analyse and evaluate the specified, implied and essential tasks passed down by the higher formations. This is a crucial step as the higher commander's intent should be very clear to the analysing AI system.

The system would then carry out a systematic process of analysing the mission variables of the enemy such as assets, terrain and weather. The AI system would parse through archived and real-time inputs of geospatial data,

The ultimate aim of AI in AOPP is to have an AI system that has the ability to organise courses of action that take into account the level of detail that is required to issue launch orders to a Surface-to-Air Missile (SAM) unit or a scramble of an operational readiness platform, after synchronising the different intelligence assets across the AI interfaces.

infrastructure data, climatological data, etc. As mentioned earlier, with natural language processing, and question and answer technology, the AI system would facilitate better understanding of the enemy.

After completion of this operational environment assessment, the AI system would be able to formulate the friendly and adversarial courses of action. The AI system utilises inputs such as satellite imagery to aid in the real-time movement conditions, say of a mobile radar unit.

The AI system would then be able to produce an updated warning order as a result of the data analysis carried out. The AI system would already contain draft warning orders in its database, with approved data fields. These data fields would be populated based on the interface between the AI system at Command Air Tasking and Strike Planning for Aerial Warfare (CATSPAW) or Air Defence Operations Room (ADOR) with the modules at the Maintenance Control Centre (MCC) and Administration Control Centre (ACC). The AI system would parallelly contain updated input data for future operations orders wherein the data fields are updated as the planning is developed and refined within the AI system.

The AI system would then generate the course of action for the commanders, both at the Command Headquarters and at the executing bases. The ultimate aim of AI in AOPP is to have an AI system that has the ability to organise courses of action that take into account the level of detail that is required to issue launch orders to a Surface-to-Air Missile (SAM) unit or a scramble of an operational readiness platform, after synchronising the different intelligence assets across the AI interfaces. The AI system would also have to enable the relocation of assets (OAMP), where necessary, in

order to achieve the best course of action. The system would also have to provide a real-time solution to developing contingencies, the biggest being attrition. The rate of attrition is highest at the commencement of the conflict and is expected to reduce as the conflict wears on. Crucial in this stage of generating COA is the selection of the target that has to be in line with the higher commander's intent and, ultimately, the strategic objectives.

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The AI system would also allow the commanders to carry out an analysis of the generated courses of action. This analysis would bring out the difficulties and coordination problems associated with the generated courses of action. The aim of this stage of operations planning would be to finally provide the commander with the best course of action to be taken. The AI system would utilise computer aided modelling and simulation for each COA. The analysis would also bring out the different stages and phases of the recommended COA. All the objectives of the individual stages and phases are clearly defined and must be clear to the executing units.

The final step of the air operations planning process would be the issuing of orders, their production, dissemination and transition. The AI generated Command and Air Tasking Orders (CATOs) would have gone through four distinct modules for analysis and updating of the data fields viz. the ISR module, the CP Module, the COT module and the Post Mission Analysis Team (PMAT) module in the AI system. The AI system would utilise the already existing medium by which CATOs are disseminated by CATSPAW. These final AI generated CATOs would be analysed and again compared with the best COA generated in the preceding process by the AI system.

One of the developments that would help in the evolution of the required algorithms is the development of Natural Language Processing (NLP) whereby programmers are available to use typical grammar and syntax

to communicate with machines rather than having to input code. Further utilisation of developments in the field of computer vision, particularly in techniques for image and video analysis would accelerate the development of AI algorithms.

To achieve an AI driven AOPP, development of an expert team, systems and natural language understanding would be required. The expert system would have the ability to solve problems, give advice, predict and finally be a body of knowledge for military planners. This expert system would operate in conjunction with a natural language understanding thereby giving the machine the ability to understand, natural language as an interface with human planners. This, however, would not be an example of a fully autonomous system as human intervention would still be involved.

Having understood the various processes in AOPP and the capabilities of AI in separate verticals, there is a need to study where and how much scope is available with the present understanding to introduce or integrate AI in each process separately. The study involves the various inputs to the process and the outcome at the end of each process of the AOPP. This is explained in the following paragraphs.

CONTINUOUS PROCESS

Operational Environment Analysis

Major inputs to this process are the intelligence data from various sources. These sources of inputs are Human Intelligence, Communication Intelligence, Signals Intelligence (HUMINT, COMINT, SIGINT) from various national and state level agencies like the Research and Analysis Wing (RAW), Intelligence Bureau (IB), sister Services like the army, navy and paramilitary services, various tri-Service institutions like the Defence Space Agency (DSA), etc and intelligence data from our own agencies like ISR platforms, own assets and meteorological data. These inputs are

combined and analysed at the strategic level to give an integrated output of the current operational environment.

Scope of AI: There is a lot of scope for AI integration in this step. Data integration tools of AI can collect data from various sources, including sensors, intelligence reports, weather forecasts and mission logs. This data can further be integrated and processed to provide a comprehensive view of the operational environment. AI has the potential to present commanders with real-time situational awareness by displaying critical information such as enemy positions, friendly forces, airspace restrictions and weather conditions. AI has an additional capability to provide a theatre-based or theme-based picture of the current operational environment. At present, the data integration and analysis is being done by the planning staff manually. The process can be automated, and verified manually to start with.

Evaluation of Own and Enemy Capabilities/ Intent

Major inputs to this process are the friendly and enemy capabilities in various domains. Broadly, these can be classified into Diplomatic, Industrial, Military and Economic (DIME) domains. While general inputs in all the domains are necessary in this process, detailed inputs in the military domain are essential in this step of AOPP. Further, specific and precise capabilities of the enemy air force in each theatre forms a major input in this system. A detailed analysis of these capabilities is done in this process which will provide a valuable output to the commander in making crucial decisions in AOPP.

Scope of AI: It is evident that most of the inputs to these processes are fairly quantifiable and, therefore, the process of analysis and compiling the outputs can be easily undertaken by an AI tool. However, verification of the results/outputs should be carried out manually, especially when it comes to the intent of the enemy. In addition, specific theatre-based assessment and evaluations of own and enemy capabilities can also be generated by AI to present the commanders with various options. For

example, the enemy air force, even if strong in numbers, may not be able to deliver in certain areas due to terrain considerations.

OBJECTIVE IDENTIFICATION AND EFFECT DETERMINATION

These two processes are heavily interlinked with each other. Identification of objectives is a process which culls out specific objectives of air operations which is ultimately aligned with the national, strategic and political objectives. Through the process of effect determination, commanders are able to determine whether the effect has been achieved on the ground as per the objectives identified. In the long run, this would aid in moving towards the end state which is the state of affairs which needs to be achieved either to terminate or to resolve the conflict on favourable terms. If the effect determination process yields contrary results, the step of objective identification has to be repeated and the effect determination process gone through once again.

Scope of AI: There is scope for developing various AI-based modelling and simulation tools that can replicate operational scenarios. These war-gaming simulations allow decision-makers to test different objectives and Own Courses of Action (OCsOA) and assess their effects. Hence, there is limited scope (as of now) of AI in objective identification but vast scope in the effect determination process.

CENTRES OF GRAVITY IDENTIFICATION

A Centre of Gravity (CoG)is defined as a point of crucial vulnerability against which serious degradation, dislocation, neutralisation or destruction would have the most decisive impact on the enemy's or one's own ability to accomplish a given military objective. This step involves identifying own and enemy CoGs. This process involves analysis of various crucial targets of the enemy and identifying their potential to become CoGs. The same analysis is done for own forces from the enemy's point of view. The targets can be static like key refineries and airfields or moving like AWACs,

political and military leadership, etc. This step comprises a tedious and lengthy process.

Scope of AI: There is vast scope of incorporating AI in this step. The ability of AI powered drones/drone swarms, satellite imagery, ISR gathering through multiple sorties, HUMINT, etc will generate a large amount of data. The same data will be used by the AI tool towards effective target selection which satisfies the definition of the CoG on the basis of the algorithm. However, the process of verification of outputs needs to be done manually.

STRATEGY FORMULATION

This process is accomplished at Air HQ wherein the air strategy is formulated to align with the national objectives. This process is also conducted at the command level based on the air strategy. The outcome is based on the detailed analysis of the outputs of all the previous processes and running various simulations and war-games.

Scope of AI: There is a vast scope of incorporating AI in this step. A Decision Support System (DSS) is a vital AI-based tool that aids commanders and decision-makers in making informed choices during various operational scenarios. The DSS integrates data, information, models, and analytical tools to assist in the decision-making process. The DSS can create different scenarios based on varying parameters, which help in analysing the potential outcomes of different decisions, allowing commanders to choose the best course of action. The DSS provides a structured approach for evaluating various courses of action. It assists in comparing the pros and cons of different strategies and their alignment with mission objectives. The DSS also assists in evaluating the outcomes of decisions based on historical data and predicted results. This feedback loop helps improve decision-making processes over time.

CONCURRENT PROCESS

Arrangement of Stages and Phases Identification.

This operational phase involves planning the arrangement of stages and phases of operations to achieve the objectives identified. It involves taking stock of all the existing resources at the operational level and planning out their utilisation as per the decided Own Course of Action(OCOA). This process involves heavy staff work by all the specialist branches and huge coordination by CATSPAW at the commands.

Scope of AI: There is maximum scope of utilising an effectively designed AI algorithm/ tool in this process. While it involves heavy staff work, it also consumes critical time. AI has lot to offer in systematically and effectively planning, processing and arranging multiple viable options to the commander.

OPERATION PLAN PREPARATION AND CONTINGENCY PLANNING

This is the next concurrent phase in which specific plans for each stage and phase need to be clearly defined. As an element of the Command HQ Operations Centre (CHOC), the Operations Control Centre (OCC) comprises the Air Defence Operations Room (ADOR) for AD operations and CATSPAW for offensive air operations. This process involves planning specific offensive and air defence missions in line with the stated objectives and OCOA.

Scope of AI: A specific AI planning tool can be developed which can analyse various databases of own assets (for example, the type and number of platforms) and targets based on stated objectives. AI can assist in the allocation of assets to specific AD operations and/or offensive operations. Another task of formulation of the Operational Air Movement Plan (OAMP) at Air HQ is an exercise which involves extensive staff work. This task can easily be undertaken by AI-based software.

INTEGRATED LOGISTICS AND MAINTENANCE MANAGEMENT

This process deals with effective management of operational logistics and maintenance towards the execution of operational plans. Pan-IAF real-time information to commanders on the status of availability of critical spares, which is currently available through IMMOLS and e-MMS will help them decide on allocation and reallocation for ensuring maximum availability of aircraft and equipment.

Scope of AI: A specific data driven AI planning tool can be developed which can analyse various databases of own resources and present options in this regard. AI will augment the existing IMMOLS and e-MMS towards prioritisation, smooth and shortest supply chains, and would predict the requirements. A larger picture through it to the Deep Neural Network (DNN) will help the operation plan

ADMINISTRATIVE ACTIVITIES

This concurrent process deals with all other important administrative activities like manpower planning, passive air defence, ground defence, etc.

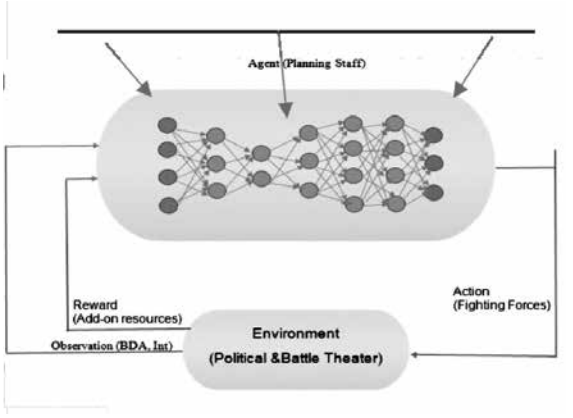
Scope of AI: There is vast scope for developing an AI tool for manpower and material management related to this process. It is always going to be the man behind the machine who is going to make a difference in the battlefield. The AI tool can help in optimum and effective augmentation of manpower. The AI tool can offer suggestions towards Province Air Defence/Ground Defence (PAD/GD).

On the basis of understanding of concurrent and current processes of AOPP and viable scope of AI in each attribute [like ISR, IAF Mission Planning Analysis and Collaboration Tool (IMPACT), Next Generation Air Ops System (NG AOS), IMINT, Visualisation and Integrated Online Profile on Meteorology (VIOM), Integrated Aerospace Safety Management System (IASMS), Next Generation Technical Air Defence Integrated Display System (NGTADIDS), ACC e-MMS, etc. known as agents], we can roughly understand the deep neural network and the design of reinforcement learning [which are the essentials for Machine Learning (ML) and Deep Learning (DL)] through

the following flow chart. The system gets progressively smarter according to the strength of the agents i.e. the amount and quality of data in individual agents and also on the number of agents and according to the weightage given to the individual agent as defined in the algorithm.

Fig 2: Deep Neural Network (DNN) in AOPP Input Layer Hidden Processing

Fig 3: Reinforcement Learning Algorithm in DNN



Proposed AI Infrastructure in AOPP

AI is data sensitive and the output largely depends on the algorithm. Both data as well as the algorithm will warrant a powerful central processing unit and a graphic processing unit. Since we already have the current infrastructure towards an operational AOPP, it will just require rearranging certain centres and a dedicated and developed infrastructure which is the need of the hour. Certain essentials are listed below, which are not comprehensive but suggestive in nature.

Data Centres.
Information Fusion Centres.
Deep Neural Networks with Re-Enforcement Learning (ML and DL)
.Modelling and War-Gaming Tools.
Decision Support Systems.
Training Centres.

The above proposed AI infrastructure can be a designed to cater for independent contingencies or it may be a comprehensive one as the machine(AI) will only identify the enemy, whether it is from the north or west is irrelevant to AI. Redundancy and security (cyber) of data needs to be completely ensured for obvious reasons. A separate duplicate AI infrastructure for the Red and Blue Teams is required for peace-time simulation training of commanders and planning staff.

To achieve a fully autonomous AOPP, there is a need for stake-holders to develop enablers of artificial intelligence at different levels of the planning process. The succeeding paragraphs will highlight the different actions that need to be taken in order to facilitate artificial intelligence in air operations planning process.

The recommendations are as follows:

- Developing an understanding of the capabilities of AI.
- Development of AI software which encompasses development of algorithms, programmes and, eventually, source code. Special teams

could be developed specifically for the algorithm and source code development.

- Development of systems for data collection (old and new), data purification and networking and ensuring consistent and seamless data flow.
- Effective use of AI in the air operation planning process. This can only be accomplished if we aim for complete digitisation of the battlefield. A step in this direction comprises the already existing systems such as IACCS, e-MMS and IMMOLS, to name a few.
- Development of a robust cyber security apparatus in the IAF that is always one step ahead of the adversary. The increased use of virtual platforms eventually results in the increased probability of cyber attacks. In this scenario too, AI and cyber security enhancements go hand-in-hand. Through AI and the use of predictive analytics, cyber attacks through the pushing of malware, data intrusions and server attacks can be overcome even before they happen.

CONCLUSION

For AI in AOPP, there will be three degrees of autonomy. The current status of AOPP is in the first degree i.e. semi-autonomous, wherein agents of the continuous and current processes work independently and then wait for the commander to take action before going onto the next stage or phase. In this state, the commander is sitting in the loop of Observe, Orient, Decide, Act (OODA). The second degree is the supervised autonomous operation, wherein the independent agents of AOPP will be given a certain degree of, or full, freedom (depending on the strength and maturity of the algorithm) to decide and act on their own, but in this case, the commander will continuously observe the quality of the decision and, if required, will override the action/decision. Here the commander will be sitting on the loop of OODA. The third degree is of fully autonomous AOPP, which will be the highest state of autonomy, wherein the commander will be out of the loop of OODA. Once the system is activated, AOPP will accomplish

the task without any communication to the commander. While we as the air force will strive to achieve this state, we will continue to ensure that the commander is sitting on the loop of OODA.

For the organisation to encapsulate AI is one of the most critical aspects of AOPP: a thorough understanding of the mechanism of AI by an expert team is essential. AI is driven by data and the organisation has to bring in culture of systematic collation of data from all the agents of the organisation, from the old data to the new data.

In a systematic way, the war machines have become faster and the speed of engagement even faster. There is an urgent need to redesign and restructure the current AOPP by augmenting it with AI, which will systematically assist the commander to have a comprehensive picture of the battlefield, with viable options to select one.