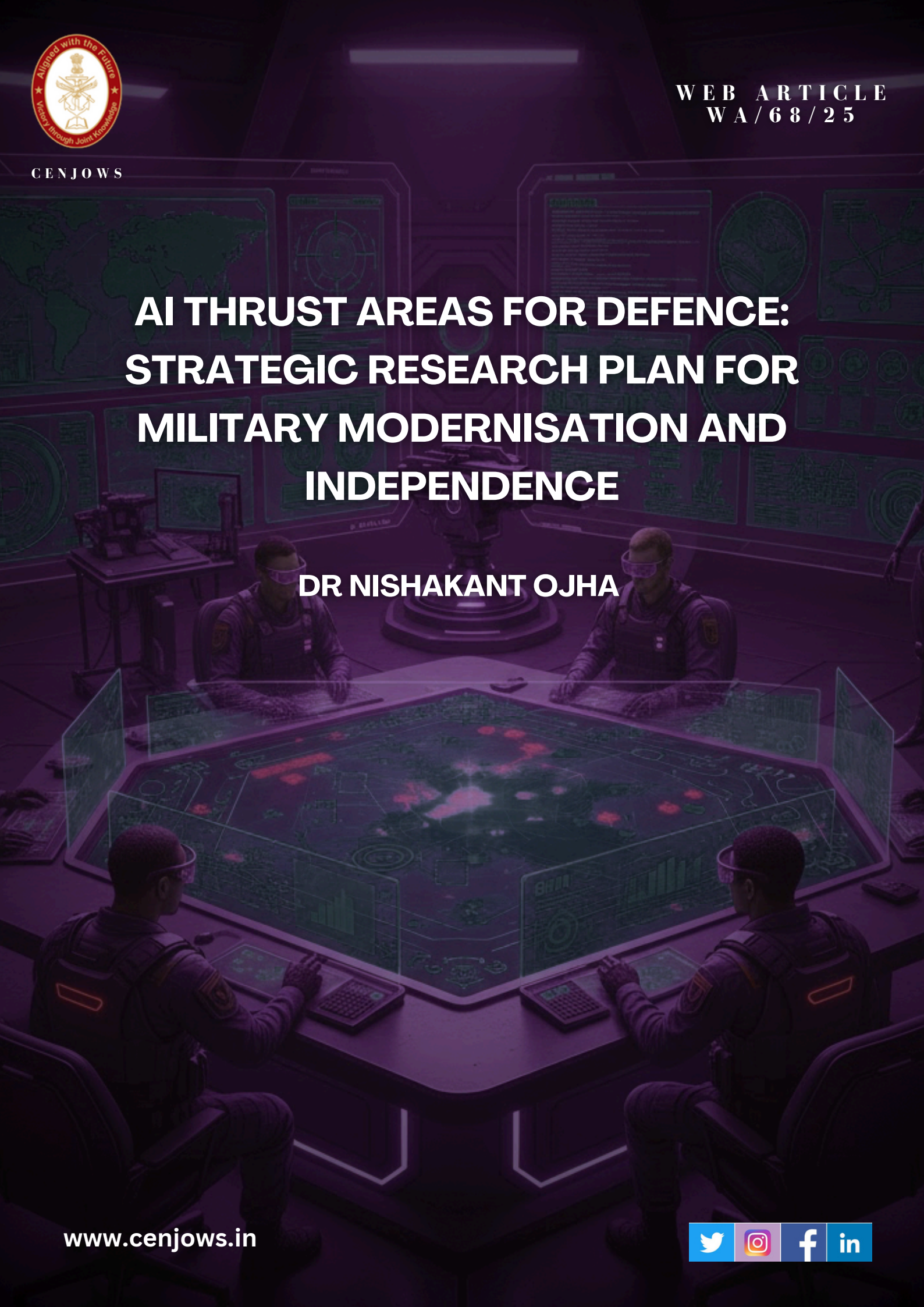

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AI THRUST AREAS FOR DEFENCE: STRATEGIC RESEARCH PLAN FOR MILITARY MODERNISATION AND INDEPENDENCE

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AI THRUST AREAS FOR DEFENCE: STRATEGIC RESEARCH PLAN FOR MILITARY MODERNISATION AND INDEPENDENCE

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Introduction

Global Strategy is influenced in different ways due to the application of artificial intelligence like cyber AI, Military semiconductors, ethical AI warfare, Automated systems, and strategic AI decision technology. This article focuses on the significance of advanced technology and how several countries have implemented it in their security forces to address current problems and create accurate, strong, and sustainable self-regulated systems to solve issues. [12]

Based on the information that is currently available, India is also leading the way in this field of study and is making great strides. MUNTRA, UGV3, and self-driven support systems[3,4] are a few examples of platforms. The teaming protocol, integrated cyber command structures, ethical AI frameworks, and semiconductor sovereignty[5] represent significant gaps. India must increase its domestic chip production, create thorough AI ethics charters, establish specialised Cyber AI Commands, and encourage academia-industry cooperation for its own technological development[6] in order to achieve strategic autonomy and operational superiority. Artificial intelligence has evolved from a futuristic idea to a powerful force that is shaping security tactics

globally. AI used to be only found in science fiction, but these days it powers systems that can sense, make decisions, and solve complex problems- all of which are essential skills for contemporary military operations.[7] Three essential components form the foundation of any successful artificial intelligence system: sensors and actuators that engage with the surroundings, processing equipment that analyses vast volumes of data in real time, and complex algorithms that identify trends and make decisions[8,9].

The revolution in military affairs

Modern defence systems are majorly affected by AI. With limited human interference, self-controlled systems like Lethal Autonomous Weapon Systems (LAWS) [10] can detect threats, assess risks, track targets, and complete tasks. Modern strategy of combat understands by unbeatable speed, accuracy, and self-reliability that controlled by this change. While fully automated AI remains an unreal dream, current deployments focus on narrow AI- specialised systems that enhance particular facets of combat. AI-powered image identification for threat assessment and predictive logistics analytics to reduce delays and preserve combat readiness are two examples. Automation in most of the military's operations reduce soldiers' workforce and provides efficiency as well. This is what India's Chief of Defence Staff, General Anil Chauhan, calls the "Third Revolution," which is powered by self-regulated technologies, artificial intelligence, and data-centric warfare.[11] Projects like Operation Sindoor show how AI-integrated strategies might address contemporary threats like hostile drones, leading to a reconsideration of systems and ideologies.[12]

Autonomous Systems: The Vanguard of Defence Innovation

Self-driven technologies are upgraded, tested, reliable and now broadly used everywhere. Robots can now function in complex, GPS-denied, and disputed scenarios thanks to developments in robot coordination, sensor fusion (LiDAR, radar, and infrared),[13] and edge AI. Boston Dynamics out of US developed a ground robot for the military, which they use in tough locations.[14] Also, we have the four-legged dog-like robot, which is the spot model, which does patrol, vigilance and delivers what the soldier needs during war. They use thermal imaging to navigate, and they also identify what the soldier requires and will drop off supplies when needed. Also, these robots

play a role in reducing human interaction and in saving soldiers' lives, which is very important.[15]

Global Trends & Technologies

Global Trends & Technologies Most recent advancements and tools need limited human control and are largely self-contained. Advanced multitasking and intelligent software, like the US DARPA OFFSET,[16] developed for drones, facilitates the military completing designed operations while communicating, data gathering, and coordination with soldiers in the field. More sophisticated graphical neural network-based drones are being developed to perform more synchronized task. Modern Sensors like LiDAR,[17] radar, IR, and RGB cameras, and drones are becoming more advanced. Such tools compute and provide data using NVIDIA Jetson Xavier, Intel Movidius and Qualcomm Snapdragon enable quick decision making ability.[18] Software ecosystems like the open-source Robot Operating System (ROS)[19] and NVIDIA's Isaac SDK[20] help to accelerate advancement. A new era of military robots has started, with autonomy, collaboration, and adaptability at the core of defence technology.

In the United States, Boston Dynamics' Spot robot has become a flexible tool for military forces, routinely deployed for reconnaissance operations that need it to navigate varied terrain, acquire real-time data, and help troops by spotting threats while keeping soldiers safe.[21] In addition to Spot, coordinated drone swarms are increasingly being used for environmental survey and precise strike missions, indicating a transition toward integrated, self-sufficient air-ground teams in US operations. In China, the Sharp Sword Unmanned Combat Aerial Vehicle (UCAV)[22] and advanced underwater drones perform critical roles in the safety of the sea. China is able to accomplish its geopolitical objectives in disputed waters thanks to these AI-powered autonomous navigation and long-term surveillance systems. Israel is working to improve missile defence technology in the meantime; unsupervised AI-based coordination is now a part of the Iron Dome system.[23] This shows how AI-driven systems can provide flexible and highly effective defence solutions in dynamic battle situations by enabling quick, automated interception of threats using a network of radars and launchers.[24]

Powering AI on the Battlefield

The development of military artificial intelligence depends on reliable, high-performance semiconductors. They must enable quick data processing at the margins, withstand challenging environments, and offer ultra-low-power computation (neuromorphic processors), radiation-resistant processors, FPGA-based learning systems, and AI accelerators like NVIDIA's Jetson series are examples of current methods.[25] To ensure security, durability, and autonomy during crucial operations, Indian Defence is growing its chip fabrication programs. Quantum-enhanced processors and integrated 3D electronics that combine multiple functions in small, sturdy packaging are part of the next wave.[26,27]

Cutting-Edge Technologies

Cognitive computers, like IBM's TrueNorth and Intel's Loihi, may now offer ultra-low-power, perpetual learning while mimicking the efficiency and versatility of the brain, making them ideal for resource-constrained automated systems, edge prediction, and always-on surveillance. Space missions and high-altitude drones require radiation-hardened chips, which are made of durable materials like silicon-on-insulator and gallium nitride to withstand ionising radiation. This ensures consistent system integrity and dependable mission-critical operation even in the presence of cosmic rays or nuclear electromagnetic pulses. Heterogeneous integration through 3D integrated circuits has enabled multi-mission flexibility, decreased size, and efficiency in computing through incorporating CPUs, GPUs, and AI accelerators into small modules[28, 29, 30]. Similarly, the use of FPGA-based devices has grown since their field-programmability allows military forces to instantly alter communications and encryption systems, increasing resistance to cyber and electronic warfare threats.[31]

The United States-based DARPA is at the top of creating radiation-resistant AI circuits, especially for space-based security platforms. [32] Through the advancement of integrated 3D heterogeneous chip design [33] and rapid radiation testing, DARPA's ASSERT and OPTIMA programs ensure that space and high-altitude mission electronics can provide state-of-the-art AI performance while enduring extreme radiation and other challenging conditions. Russia is just beginning to deploy the Uran-9 combat robot, [34] which demonstrates how reconfigurable hardware improves battlefield flexibility and resilience by utilising FPGA technology[35] for adaptive real-time

mission control, encryption, and robust communication. In the meantime, Israel and other European nations are pushing forward with the incorporation of low-power, incredibly effective AI chips into contemporary self-driving cars and missile defence systems.[36]

Ethical AI & Governance: Upholding Responsibility in Warfare

The widespread use of AI in combat raises significant ethical questions. Existing frameworks of accountability, human judgment, and adherence to international humanitarian law are all brought into question by autonomous systems. Technologies that encourage ethical compliance include explainable AI (XAI) frameworks, [37] fairness-aware algorithms, and operational policies that need human supervision[38,39]. International initiatives combine innovation with ethical and legal requirements to regulate responsible AI use.

Emerging Tools & Frameworks

To ensure responsible deployment in high-risk scenarios, new defence automation gadgets and structures are currently constructed with strong responsible controls. because of explainable AI models,[40] particularly SHAP and LIME, which have become standard tools for enabling transparent artificial intelligence-driven actions, operators and commanders are now able to understand the reasoning behind self-sufficient action.[41] Model building and validation pipelines are incorporating fairness and bias mitigation tools like Fairlearn and AI360 to lessen the possibility of inadvertent bias. Human oversight and ultimate control over crucial, frequently fatal decisions must also be preserved in Human-in-the-Loop (HITL) and Human-on-the-Loop (HOTL) system architectures.[42]

Global Developments

In order to standardise the ethical use of AI in military contexts, organisations like the UN and NATO are actively promoting governance standards and creating guidelines for compliance and accountability.[43] In countries like the US and Europe, there is a push towards implementing transparency and equity in self-governing enforcement systems in order to ensure compliance with legal and ethical requirements. Israel has gone one step further and ensured that deployments adhere to recognised international law and humanitarian standards by integrating ethical evaluation systems into its AI-powered defence operations.[44]

Cyber AI: New Frontiers in Digital Warfare

Cyber applications of artificial intelligence include both offensive capabilities like automated vulnerability testing and AI-generated communications, as well as defensive ones like threat prediction, real-time anomaly detection, and federated learning for cooperative security. India's cybersecurity divisions use artificial intelligence-powered SOCs, while research focuses on quantum-resistant cryptography and autonomous cyber-defense.[45] Future digital warfare systems will be incredibly evolving and self-adjusting, necessitating sophisticated training in skills and governance.[46]

State-of-the-Art Technologies

Modern artificial intelligence is currently being used in military cyber defence to detect threats quickly, respond adaptively, and ensure system security. Natural language processing techniques based on huge language models (such as BERT and GPT)[47] enable AI systems to handle and analyse massive amounts of raw information from threat feeds, interactions, and the dark web, offering early warning against new types of malware or targeted assaults.[48] Machine learning algorithms for recognising anomalies regularly track network behaviour, detecting unusual activity before it spreads. Federated techniques for learning are increasingly deployed, enabling several Defence organisations to collaborate to train AI models without disclosing sensitive raw data, thereby retaining operational confidentiality while improving collective cyber intelligence.[49]

Global Instances

Around the world, top powers have made significant advances in this field. In the United States, Cyber Command has extensively integrated AI for both proactive cyber defence and realistic offensive wargaming, mimicking conceivable adversary strategies to boost national resilience.[50] Russia and China vigorously deploy AI-driven offensive measures to penetrate networks, carry out highly adaptable electronic warfare, and spread propaganda.[51] Meanwhile, NATO is leading multinational initiatives to establish frameworks and operational norms for using self-learning AI programs to secure digital assets with minimal human interaction. These attempts demonstrate how AI is evolving the cyber domain into a highly dynamic, intelligent, and reactive battlefield.[52,53,54]

Tactical AI Decision Systems: Command & Control Transformation

Machine learning, sensor fusion, and human-computer collaboration are used by tactical AI systems to enhance strategic command choices. Combat data is integrated by platforms like India's Akash Teer30 to enhance logistics and threat response. Simulation and explainable tools can educate humans to increase logical thinking during stressful situations. Development allows self-controlled tools to complete the task with negligible human interference.[55,56] To accurately identify attacker positions, prioritise threats, and facilitate prompt decision-making, sophisticated machine learning algorithms analyse data from various sources, such as image, audio, and radar sensors. [57] Collecting data from satellites, drones, ground vehicles, and wearable soldier equipment, multi-sensor data fusion increases combat vision by producing an accurate and up-to-date image. To ensure effective communication and accountability during crucial times, Human-Artificial Intelligence Teaming (HAT) systems strive to achieve a careful balance between the speed and accuracy of robotics and exact judgment.[58] Mission rehearsal and planning are also improving as a result of the usage of simulation programs and digital twins, which enable military personnel to preview, edit, and stress-test strategic choices in risk-free virtual environments[59,60].

Current Scenario & Needs Across AI-Driven Defence Systems in India

India has made tremendous headway with the Muntra Unmanned Ground Vehicle (UGV)[30] and the increasing use of imported drones equipped with domestic intelligence analytics, which improves both surveillance and operational planning[30]. AKU Air Command Platform supervise and upgrade accuracy of the air defence system by quick decision-making power boosting[61,62]. India import Specialized chips, radiation-hardened and neuromorphic processors from global vendors. local semiconductor manufacturer available in Hyderabad and Bangalore. The small size of the chip makes it difficult to prepare and use easily in ministry gears. Academia-industry partnership in India is making progress in such fields and developing some cybersecurity and threat detection tools. More focused research is required on quantum-safe encryption technology, integrated security operations centres, and cyber command structures.[63]

Strategic Recommendations

To secure the Indian defence system in future, transparent, safe, human-controlled and self-regulated advance machine needs to be developed. The gap bridge by academia-industry collaboration to develop a reliable and secure AI processor to make defiance system more powerful. It is necessary to have AI skills nowadays to improve staff's AI skills training sessions, and hands-on training programs are important. Investment in cutting-edge technology will make the defence system safer and more accurate. Along with domestic initiatives, India firmly aims to align global governance for artificial intelligence with its values. Combined research, development, and production will provide adaptable and resilient defence capabilities, while ethical incorporation with scientific responsibility will position India as a global leader in pioneering military artificial intelligence.

Conclusion

How well India employs Artificial Intelligence will shape its defence strategy. Success will call for investments in autonomous systems, ethical and cyber-safe AI, advanced military IT, and affordable decision-making AI. Also needed are a secure cybernet and homegrown technology. Where people are in control, AI is explainable, and rule sets are clear, the modernisation of defence can respect democracy and human rights. How rapidly India adopts new technologies will determine its capability to lead the global order on security. Ethically, accountability will need to be at every step.

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