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# Defense Paper Series

## The Need for A Lifecycle Approach to AI-Enhanced Autonomy

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This paper series includes discussion papers written by SCSP advisors regarding the development of the 2025 National Defense Strategy. The views and opinions expressed in this paper are solely those of the authors and do not necessarily reflect the views or positions of SCSP.

## Summary

The Department of Defense must adopt a comprehensive lifecycle framework for the development and operational use of AI-enhanced autonomous systems. This is one of the most consequential steps the Department can take to ensure strategic competitive advantage in the coming decade.

Integrating AI-enhanced autonomy across the U.S. military will demand not just novel technologies, but the DoD will need to pursue continuous experimentation, modernization, and reform before a peer adversary defines the future of warfare for us.

Unlike piecemeal innovation or incremental acquisition reforms, a lifecycle approach ties together design, testing, doctrine, training, and sustainment in one coherent framework that keeps pace with AI and robotics/autonomy's rapid evolution.

This summary is supported by six specific priorities for implementation, outlined at the end of this paper.

## Background

Over the next decade, the DoD's ability to deter and, if deterrence fails, to fight and win will depend to a significant extent on its ability to accelerate and scale AI-enhanced autonomous systems in all domains. The Department has made steady, but only incremental and linear, progress in developing AI and autonomy. There has been insufficient progress in the comprehensive integration of AI and autonomous systems.

The Department is not prepared for complex all-domain combat operations against a peer adversary involving potentially thousands of crewed, legacy, advanced, autonomous, and AI-enhanced autonomous systems. These systems will operate simultaneously, and in some cases without human intervention, while under constant kinetic and non-kinetic attack. The ramifications extend across every aspect of the Department—from training and education to doctrine, operating concepts, testing, organizational redesign, C2, contracting and acquisition, legal, and sustainment.

Given the rapid pace of development of increasingly advanced AI over the next few years, to include highly capable reasoning models and agentic AI, the Department must accelerate plans for integrating these capabilities with robotics and autonomous systems, from battlefield logistics systems through multi-domain lethal autonomous weapons systems.

Considering the consequences of the proliferation of all-domain intelligent autonomous systems, in which the ability of humans to intervene during operational employment will become increasingly limited, the Department must take a rigorous, full lifecycle approach to the design, development, testing, training, fielding, and sustainment of these smart autonomous systems.

Since China and Russia are advancing “intelligentized warfare” doctrine and are committed to accelerating their own development of AI-enhanced autonomous systems—up to and including lethal autonomous weapon systems—it is imperative that the DoD act with the appropriate sense of urgency. The DoD must also accelerate its efforts to deny, deceive, and defeat adversarial AI-enhanced autonomy.

As AI-enhanced autonomous systems become widespread, so too will adversary countermeasures. DoD systems must be designed not just to work, but to prevail, in contested, deceptive, and adversarial conditions.

DoD Directive 3000.09, *Autonomy in Weapon Systems*, directs senior-level review of autonomous and semi-autonomous systems—which includes AI-enhanced systems—before formal development and again before fielding. OSD and the Joint Staff, in coordination with the military Services, should use these mandated reviews to develop a comprehensive framework for addressing the most relevant issues pertaining to the development, testing, deployment, and sustainment of all AI-enhanced autonomous or semi-autonomous systems.

The DoD should develop a similar framework for use by operational- and tactical-level commanders, who will be held responsible for the employment of these autonomous systems once they are approved for deployment.

For AI-enhanced autonomous systems, the challenge for the DoD is not just defining the role of human input, but determining where, when, and how it must be applied for sustained operational advantage.

## The Framework

To implement a lifecycle approach, the Department should adopt a common framework that integrates legal, technical, operational, and training considerations across each phase.

The framework needs to address the following stages of the AI-autonomy lifecycle:

- Before system development
  - Identify and address general legal, ethical, and related technical concerns
  - Provide the rationale for military development and use of AI-enhanced autonomous systems, and clarify the process for translating warfighter needs into hardware and software system requirements
- Research and development
- Procurement and acquisition
- Testing, evaluation, verification, and validation (TEVV)

- Education, training, and human-machine integration
- Political, policy, and strategic considerations
- Operational-level command and control (C2)
- Tactical employment
- Review, reuse, and/or retire

## Context

The world's militaries—led by the United States and China—are racing to fuse AI with autonomy, not because today's technology is perfect, but because the potential future advantages are simply too great to ignore. These systems promise better decision-making, faster operations, and more precise effects, delivered at a scale and speed humans alone cannot match.

AI-enhanced platforms, sensors, decision-support tools, and weapon systems will be central to future military and intelligence operations. In practice, AI delivers the most value through **augmentation, acceleration, and automation**—generally in that order. Machine learning, deep learning, generative AI, and now agentic AI are poised to drive exponential gains in autonomous systems.

Military AI is progressing through four stages: **perception** (detecting and identifying objects and patterns—what Project Maven achieved with computer vision and NLP in 2017); **context** (combining perception with language and early generative AI to create richer situational awareness, from roughly 2020 onward); the progression to **reasoning**, which is ongoing (enabled by today's frontier models, capable of drawing inferences and weighing options); and **agency** (the ability for systems to initiate and executing actions with minimal human supervision based on human-defined goals, blending perception, context, reasoning, AR/VR/XR, robotics, and autonomy), 2026 and beyond.

Agency includes **embodied AI**, where digital sensing and reasoning directly control physical-world actions, and human guidance delivered upstream will have downstream physical world consequences.

The aim should be for AI to assist humans in making more informed decisions, and for AI-enhanced autonomous systems to take actions based on human-defined and human-bounded conditions.

## Issues for Consideration

Human-Machine Integration. Optimizing the integration of humans and AI-enhanced machines will be one of the most important, and defining, aspects of future military operations. Humans and machines each have distinct advantages, but the relatively immature state of AI today makes it difficult to predict exactly how those will evolve. The balance between human and AI decision-

making won't be fixed or linear. It will vary based on mission type, the tempo of battle, the domain of operations, and the relative maturity of the technology in question.

The DoD needs to clearly define the roles, responsibilities, and interdependencies between humans and smart machines. The goal is to maximize the benefits of emerging technologies without becoming subordinate to them.

This demands an entirely new approach to training: more, and different kinds of, experimentation, simulations, exercises, and wargaming before AI-enhanced autonomous systems are fielded operationally. That is the only way operators will gain sufficient confidence in such systems, before deciding whether, and how much, to rely on these systems in real-world missions. Campaign-level experimentation, including wargaming and red-teaming, will be essential to pressure-test autonomous systems before operational fielding.

In addition, these efforts should consider both technology readiness levels (TRL) and human readiness levels (HRL) and incorporate continuous assessments of integrated human-machine performance. The consideration of HRL, while always important, becomes critical for AI-enhanced systems that depend on continuous human interaction, as opposed to traditional pre-AI systems that primarily report results for human consideration. Substantial and sustained human intervention has compensated for poor HRLs in earlier and current fielded military systems. In future AI-enhanced systems, human-machine integration must accord equal consideration to HRL and TRL.

During testing, training, and fielding, overall integrated human-system performance can be optimized through continuous human feedback to the system as it returns its results.

AI Assurance and Assured Autonomy. The faster the DoD accelerates toward an AI-enhanced future, the higher the stakes become if autonomous systems fail. The DoD must prove—not just assume—that AI-enhanced autonomous systems will perform as intended long before they are deployed, and even longer before humans are removed from the equation. Operators must know these systems inside and out. Especially their operating envelopes, limitations, failure modes, and exactly how—and when—to intervene when needed.

Increasingly advanced autonomy demands equally advanced test, evaluation, verification, and validation techniques. Not only for hardware and software separately, but for the fully integrated hardware-software-AI system under conditions that match anticipated operational conditions to the maximum extent feasible. That demands high-fidelity modeling and simulation, digital engineering/digital twins, and use of new capabilities like NVIDIA's Omniverse. It also calls for acceleration of the efforts underway by TRMC to modernize the DoD's entire test and evaluation infrastructure.

Independent red-teaming and adversarial testing must also become standard practice—both because of limitations within the hardware and software, and the certainty of dedicated adversarial attacks.



Effective implementation will require deliberate, structured discipline across the entire AI lifecycle.

## Operational Considerations

- **Not all AI is the same**, either in composition or performance. Distinguish between *AI-enhanced decision support systems* and *AI-enhanced weapon systems*, up to and including lethal autonomous weapon systems or LAWS. Almost all decision support systems will retain some human oversight, while certain AI-enhanced weapon systems could have lethal, irreversible effects with limited or no human intervention after release.
- **Not all risks are equal**. Use a risk management framework to evaluate, mitigate, accept, or reject risks. One of the goals of the 3000.09 senior-leader reviews should be to define each system's operating envelope, anticipate foreseeable outcomes, and apply **technical (hardware and software), policy, and procedural (ROE, SPINs, etc.) controls** throughout the lifecycle to mitigate high-risk scenarios while delivering required performance.
- **No first use in combat**. Never introduce advanced AI systems, especially AI-enhanced autonomous or semi-autonomous weapons, for the first time in combat. Validate them in training, experiments, exercises, and wargames first.
- **Integrate legal review early and often**. Command lawyers should ensure AI-enhanced autonomous systems comply with International Humanitarian Law/Law of Armed Conflict and recommend additional measures for legal compliance and accountability.
- **Understand recall and termination capabilities**. As directed by 3000.09, commanders must know if and how AI weapon systems can be recalled, diverted, or neutralized after launch.
- **Design new warfighting operational concepts**. Warfighters need to develop and regularly test creative operating concepts to reflect the ubiquity of AI and autonomous and robotics systems, seamlessly integrating remaining legacy hardware and software systems with newly-fielded AI-enhanced systems. Operating concepts need to be refined constantly based on field feedback. Mosaic warfare, for example, addresses the challenges of C2 in a military comprising large numbers of autonomous and intelligent systems. It relies on a combination of human command and AI-enabled machine control, to include widespread use of multi-modal AI agents, for the "rapid composition and recomposition of a more disaggregated" military force. AI is used throughout the DoD to "empower decision support tools that enable commanders to manage rapid and complex operations," making "military units and platforms more numerous and re-composable."
- **Prepare for boundaryless C2, redesign C2 structures, and empower junior leaders**. The evolving landscape demands a reimagining of traditional C2 structures, emphasizing flexibility, empowerment, resilience, and rapid adaptation. Tactical units operating in an environment where information propagates instantaneously and where autonomy is ubiquitous, can generate global effects. The Department needs to understand how mission command should be redefined in the AI-enhanced autonomous era. Junior warfighters will be instrumental in shaping future C2 by pioneering operational concepts that balance human command with AI-driven machine control. As AI capabilities continue

to advance, military leaders must foster a culture of continuous learning and innovation, ensuring that human judgment remains at the core of decision-making while leveraging AI's enormous potential to enhance operational effectiveness and responsiveness across all domains.

- **Plan for sustainment.** Clarify how AI-enhanced autonomous systems will be maintained, updated, and resupplied in contested environments.

**Never assume interoperability.** Build it together now if the DoD expects it in the future

## Emerging Issues

- **Cascading effects, online learning, and emergent behaviors.** As AI moves from complicated to truly complex, it will be necessary to understand the potential for emergent behaviors and the cumulative, cascading risks likely to result when many different AI-enhanced autonomous systems are connected across extended networks.
- **Escalation risks.** Escalation risks rise when compressed decision cycles outpace human oversight. The challenge is not just technical, but also operational and cognitive. AI systems that respond in milliseconds may inadvertently bypass the slower, deliberative human checks that normally prevent inadvertent escalation.
- **Ethical delegation of lethal force.** The DoD needs to determine at what point delegating use-of-force decisions to AI crosses an ethical line. The goal is not to figure out how to make machines ethical—which is impossible—but to use AI to help humans make better-informed ethical decisions.
- **The control challenge, black box challenge, and the accountability challenge.** These are inherent differences between traditional and AI-enhanced systems, and must be addressed in design, testing, and deployment. They are not solvable once-and-for-all “problems,” but persistent features of the technology.
- **Swarming systems.** Intelligent swarms will progress far beyond the distributed and coordinated drone operations seen today in Ukraine. These will be distributed, intelligent systems that adapt in real time without a central controller, leader drone, or even an internet connection.

**Counter-AI and counter-autonomy.** AI and autonomy will follow the same cat-and-mouse dynamic that has accompanied every other disruptive technology throughout military history: action, followed by counteraction, counter-counteraction, and so on in perpetuity. The DoD should assume only temporal advantages rather than “autonomy dominance.”

## Six Priorities

1. Develop and promulgate a framework for a lifecycle approach to AI-enhanced autonomy, tailored for use from the strategic to tactical level

2. Increase, accelerate, stabilize, and allow flexible funding for AI, autonomy, and DoD-wide digital modernization
3. Rapidly acquire commercial C2-related software/hardware, relying primarily on the “hardware-enabled, software-centric” principle
4. Embrace field to learn principles
5. Enforce MOSA/OMS/UCI and interoperability across the Services and with allies and partners

Expand and repurpose warfighter-centric experiments, wargames, and exercises (like the GIDE series of events) to refine C2 tools and concepts like Mosaic warfare, and to test the limits of human-machine integration in real operational environments.

## Conclusion

Advocating for a comprehensive lifecycle framework for AI-enhanced autonomous systems should be a priority for the next National Defense Strategy because it would ensure the Department of Defense treats developing these systems not as a collection of isolated projects but as an enduring capability woven into every phase of force development. This framework would provide the Department with a mechanism to continuously evolve alongside rapid technological advances, preventing obsolescence and accelerating operational learning. By embedding lifecycle management into the NDS, the Department of Defense will maximize its ability to harness AI and autonomy as sources of enduring competitive advantage and ensure that America—not its adversaries—defines the future character of war.