

EMERGING AND DISRUPTIVE TECHNOLOGIES INTEGRATION AND NATO'S OPERATIONAL AND STRATEGIC POSTURE

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Abstract: *This article explores the strategic implications of integrating Emerging and Disruptive Technologies (EDTs), including AI, autonomy, quantum, and hypersonic systems, into NATO's operational doctrine and warfighting capabilities. By analysing doctrinal shifts, lessons from the Ukrainian conflict, and the evolving role of unmanned aerial systems (UAS), the study reveals how NATO's Allied Command Transformation (ACT) and strategic foresight tools enable proactive adaptation to future threats. The article employs comparative-descriptive methodology and doctrinal content analysis to assess NATO's transformation frameworks and their operationalization through ACT initiatives. It concludes that anticipatory innovation and inter-domain convergence are crucial to NATO's deterrence posture in a contested security environment shaped by peer adversaries, hybrid warfare, and technological proliferation.*

Keywords: *drones, hybrid warfare, multi-domain operations*

1. INTRODUCTION

Are any geo-political side effects when utilizing drones on a large scale?

Over the course of history, the evolution of military systems has changed the physiognomy of warfare, doctrinal orientations, tactics and procedures. In recent decades, such a major shift in the way modern conflicts will be fought, whether unconventional or conventional, is foreshadowed.[16]

The integration of Emerging and Disruptive Technologies (EDTs) into NATO's operational and strategic posture is reshaping the Alliance's force structure, capability development, and doctrinal alignment. EDTs, including artificial intelligence (AI), autonomy, quantum technologies, hypersonic, and biotechnologies, present both opportunities and threats. [1]

The Alliance's embrace of these technologies is not merely additive but transformational, requiring multi-domain interoperability, agile experimentation, and digitally enabled decision-making frameworks. Through Allied Command Transformation (ACT), NATO has launched the *Emerging and Disruptive Technologies Implementation Roadmap*, designed to accelerate technology adoption and guide member states in synchronizing innovation with interoperability. The result is a shift toward more flexible, responsive, and anticipatory warfighting concepts, laying the groundwork for a Multi-Domain Operations-enabled Alliance. The development of Unmanned Aerial Systems (UAS) has introduced profound geopolitical consequences by expanding the strategic military toolkit available to state actors. These systems enable states to project power and enforce regional interests with reduced political risk and deniability.

As noted by Supreme Allied Commander Europe, General Christopher Cavoli, *“adaptation in contact is no longer enough. We need to adapt in anticipation.”* [14] This call for anticipatory adaptation underscores NATO's need to evolve beyond reactive force design and instead institutionalize foresight, resilience, and innovation at the doctrinal level.

I was a direct witness to such radical doctrinal and conceptual transformation, participating to all NATO Military Committee meetings between 2023-2025. To meet this challenge, NATO must synchronize its conceptual frameworks with rapid technological experimentation, particularly in the realm of autonomous and semi-autonomous systems. Such systems are not simply tools, they are enablers of new forms of command and control, distributed lethality, and precision engagement.

In the context of the ongoing war in Ukraine, Russian forces have systematically employed drones to achieve two interlinked objectives: precision deep-strike targeting of infrastructure and population, and the psychological erosion of Ukrainian civilian morale

Russian forces employ a wide array of unmanned aerial vehicles (UAVs) to strike not only military targets but also critical infrastructure and densely populated civilian areas. These operations extend beyond tactical utility; they serve a deliberate psychological objective.

This strategy blurs the line between conventional and irregular warfare, weaponizing fear and destabilizing public morale.

The lessons emerging from the Ukrainian conflict reveal profound shifts in both technological adaptation and doctrinal transformation. This war has accelerated the fusion of conventional, hybrid, and cyber capabilities into a multifaceted approach to warfare, wherein state and non-state actors employ *“all instruments of national and multinational power to pursue political objectives.”* [25]

The integration of drone swarms, loitering munitions, electronic warfare, and information operations underscores the *“evolving character of conflict”* [2] and the urgent need for flexible, resilient, and technologically enabled force structures.

The accelerated development of unmanned aerial systems (UAS) has necessitated their integration not only into traditional military operations and force structures but also into planning cycles and unconventional operational domains. UAS now influence decision-making at every level of command, requiring adaptive doctrines, revised operational concepts, and technology-informed leadership. [3]

Allied Command Transformation (ACT), headquartered in Norfolk, Virginia, is the NATO body responsible for capability development and technology integration. *“Emerging technologies, however, function as a double-edged sword. While they offer unprecedented advantages in surveillance, strike capability, and autonomy, they also introduce new vulnerabilities, such as electronic warfare, spoofing, and rapid obsolescence.”* [5] Under the leadership of General Philippe Lavine and Admiral Pierre Vandier, ACT leads efforts to experiment with and implement UAS, AI, and multidomain connectivity across the Alliance. In my role as SACT Representative to Europe (since July 2023), I have observed the direct application of these strategies in high-level transformation policy and joint capability development. Secretary General Mark Reutte asserts the continuous support for Ukraine in next years.

2. METHODOLOGY

This article employs a comparative-descriptive research method, reinforced by strategic foresight and predictive modelling techniques.

The analytical framework incorporates doctrinal content analysis, contrasting NATO conceptual documents, such as the *NATO Warfighting Capstone Concept* (NWCC), the *Strategic Concept 2022*, and the *NATO Command Structure (NCS) Adaptation* initiative, with operational data from recent NATO and Ukrainian applications of Unmanned Aerial Systems.

The study further integrates empirical evidence from NATO Allied Command Transformation (ACT) outputs, “Romanian Military Strategy guidelines (2021), and open-source operational assessments.”[25]

This multifaceted approach enables the identification of technological convergence points, doctrinal asymmetries, and resilience gaps, providing a grounded yet forward-looking evaluation of NATO’s evolving counter-terrorism and UAS integration frameworks.

3. NATO TRANSFORMATION PROCESS

Peer competitors to NATO can be expected to employ UAS at the same level of technology, and under comparable operational principles, as the Alliance.

3.1. *NATO Warfighting Capstone Concept (NWCC)*

How do we define NATO vision for transformation, adoption of the new technologies, rebalancing deterrence and defence posture, to be better positioned in the future? The need for future transformation is underlined in NATO Warfighting Capstone Concept, which six-words best describe this ambition – we need to out-think, out-pace, out-fight, out-excel, out-last, and out-partner.

NATO Warfighting Capstone Concept (NWCC) represents the Alliance’s foremost doctrinal effort to guide warfare development and long-term strategic adaptation. The *NATO Warfighting Capstone Concept* (NWCC) [10] represents the Alliance’s most advanced framework for warfare development, serving as a central doctrinal tool to guide strategic innovation and force transformation. It focuses and synchronizes efforts across domains to build military advantage, proactively shape the operating environment to the Allies’ benefit, and foster convergence between operational needs and technological capabilities. “Critically, the NWCC expands the decision space for political authorities by “generating flexible military options that impose strategic, operational, and tactical dilemmas on adversaries, thereby strengthening NATO’s deterrence posture.” [9]

As a foundational framework, the NWCC seeks to synchronize military modernization across Allied nations by identifying priority areas for capability development, operational experimentation, and doctrinal evolution“.[9] It enables NATO to maintain a competitive military advantage and to proactively shape the operational environment in ways that leverage the Alliance’s collective strengths. “Importantly, the NWCC expands the decision space for political leadership by offering a wider array of calibrated military options. These options are not limited to force application; they are also designed to impose strategic, operational, and tactical dilemmas on potential adversaries, thus enhancing deterrence credibility while preserving escalation control.

By linking strategic ends with adaptable military means, the NWCC serves as a critical tool in enabling NATO’s long-term resilience and warfighting readiness.

NATO Warfighting Capstone Concept (NWCC) is part of the coherent package of NATO Military Authorities best military thinking. Along with the 2020 Concept for Deterrence and defence of the Euro-Atlantic Area, the NWCC implements the 2019 NATO Military Strategy, a renewed approach setting out Alliance military-strategic objectives and the ways and means to implement them. [3]

The changing and evolving security environment puts the Alliance's continued success at risk. While NATO remains a defensive alliance, the operating environment demands new ways of thinking, organizing and acting.

Globalizations, technological driven society instability, rapid escalation of the conflicts, are common characteristics of the future. *"One thing is for sure; the nature of war will remain the same. Violence, having a political aim"*. [9]

Russia and terrorist groups and organizations will continue to threaten the Alliance whilst the role and impact of China in particular, will grow. The operating environment is widening beyond traditional military bounds, with competition among different actors becoming more persistent across all instruments of power. This environment also features more diverse actors, with new weapons and technologies employed in new ways.

NATO Warfighting Capstone Concept (NWCC) offers an aspirational North Star vision for warfare development initiatives and the opportunity for engagement with all those who share the values of the Alliance.

Five major imperatives are distinguished in this vision: cross domain command and control, resilience, cognitive superiority, influence and projection of power. Therefore, the NWCC provides a description of the 2040 operating environment and future warfighting to identify implications for the future Military Instruments of Power.

The warfare development imperatives provide an organizing principle that promotes coherence across the breadth of warfare development efforts. They offer a new, forward-looking multi-domain (land, maritime, air, cyber, and space) and cross-instruments of power approach to military thinking, organizing and acting. They are immediately usable and implementable through the lines of delivery developed with the support of Allies, Supreme Allied Commander Europe, operational commanders and NATO HQ staffs, and engagement with Allies' academic communities.

What would be the steps envisioned by ACT, to transform NATO?

"Firstly, by improving our strategic understanding of the current and future global security landscape". [10] The success of the Alliance hinges on ability to tailor and scale-up NATO's transformation to shape and contest that environment. In considering the transformation process, future geopolitical trends are important, as are military technological advances. Technology and science, industry and academia are the scanning tools for tomorrow's horizon. Experimentation and testing are necessary steps to integrating future capabilities. It will also help up improve our cognitive superiority and understanding how to impact decision making calculus of our adversaries. Achieving this imperative, requires secure and rapid dissemination of Intelligence analysis tools to all operators. Achieving a decisive cognitive, superiority implies a rapid decision cycle, a robust and fast targeting process that implies technological progress at the tactical and operational levels and much more.

Secondly, by pushing boundaries and forging a collective capability to deliver multi-domain operations, flexible command and control, and unwavering interoperability. ACT's led work on Future Force Study augments NATO's ability to anticipate future force requirements in operational environments, including developments identified at the tactical level.

This study complements the NATO Defence Planning Process and aims to provide the Alliance with the means to shape future defence investment plans. But development of these capabilities can't be based on theoretical thinking alone. It must be linked to the research and development within the defence industry and aligned with maturing of key new capabilities. Therefore, interaction with the scientific world is as important for ACT's work as direct cooperation with military industry.

Thirdly, by leading digital transformation implementation efforts, particularly on Data and AI. We are transforming currently from a platform -centric force to a data-centric force. This process is not easy and implies important investments. This will undoubtedly have an impact on Command and Control, Electronic Warfare, Cyber, Joint effects and Joint Targeting. ACT is constantly interested in integrating AI in military decision-making process, starting from the tactical level, all the way to strategic decision-making.

A fourth dimension of NATO's warfare development approach is its sustained commitment to engaging relevant civilian and institutional audiences, including national stakeholders, academic communities, and the private sector. Through strategic dialogue and outreach, the Alliance actively taps into the intellectual capital and technological innovation distributed across member nations and commercial ecosystems. Forums such as the *Allied Warfare Development Agenda (AWDA)*, the *NATO Space Symposium*, the *Multi-Domain Operations Conference*, the *NATO Industry Forum*, and the *Strategic Foresight Symposium* provide Allied Command Transformation (ACT) with "*crucial platforms for cross-sectoral engagement, enabling the organization to challenge legacy mindsets, confront conceptual stagnation, and mitigate bureaucratic inertia.*" [1]

These venues enrich NATO's capability development process by integrating insights from scientific research, defence experimentation, and commercial technology roadmaps. The ubiquity of emerging and disruptive technologies (EDTs), including cyber tools, electronic warfare (EW) systems, unmanned platforms, counter-UAS capabilities, and robotics, highlights the convergence point between industry, academia, and military transformation. ACT's ability to harness these partnerships is vital to the modernization of NATO's force structure, the evolution of military doctrines, and the "*adaptation of education and training frameworks necessary to counter both existing and future threats.*"[11]

Finally, time is not a luxury for NATO. We need a rapid and profound transformation to keep our edge, and we need it now. When acquired or employed by malign actors, emerging technologies quickly transition into disruptive technologies, fundamentally altering the character of conflict.

The survivability and relevance of modern military forces increasingly depend on their ability not only to master these technologies but also to detect, neutralize, or mitigate their hostile use in contested environments.

Understanding and countering both state and non-state exploitation of dual-use technologies is no longer optional, it is central to deterrence and operational success.

The contemporary conflict environment is increasingly characterized by complexity and elusiveness, where conventional military operations are fused with hybrid and indirect approaches. Adversaries combine kinetic actions with non-kinetic effects, particularly in the space, cyber, and electromagnetic (EW) domains, to degrade, deceive, or destabilize.

When these capabilities are coordinated with non-military instruments of power, including diplomatic, informational, economic, legal, and cultural tools, the potential for escalation outside the boundaries of traditional conflict becomes substantial. In such environments, national resilience and societal preparedness are no longer strategic afterthoughts, they are preconditions for governance continuity in times of crisis and war.

A central priority of NATO's Allied Command Transformation (ACT) is the design and facilitation of future-ready capabilities that enable the Alliance to operate as a fully integrated Multi-Domain Operations (MDO) force. "*This transformation aims to ensure interoperability and convergence across land, air, maritime, cyber, and space domains, enabling synchronized effects and rapid decision-making in contested environments.*" [1]

Through doctrinal innovation, capability development, and multinational experimentation, ACT provides the strategic framework necessary for NATO's adaptation to high-intensity warfare and hybrid threats.”[2]

3.2. How do we need to adapt for the tomorrow's fight or What do we learn from Ukrainian conflict?

Future warfare will be increasingly defined by the convergence of autonomy, mass deployment, and multi-domain integration. Systems capable of **autonomous operation**, particularly those enhanced by artificial intelligence (AI), will dominate not only reconnaissance and surveillance roles but also direct engagement and electronic warfare functions.

According to projections from NATO's Allied Command Transformation (ACT), Unmanned Aerial Systems (UAS) will evolve beyond their traditional intelligence, surveillance, and reconnaissance (ISR) functions to become autonomous decision nodes within distributed, self-healing command-and-control (C2) architectures.

These platforms will enhance NATO's responsiveness, adaptability, and resilience in contested environments. However, the adoption of these technologies will also introduce new vulnerabilities, including adversarial AI attacks, data spoofing, and system misidentification. There is a future need for a better balance between NATO deterrence and defence posture. “*Deterrence by denial is incomparably cheaper than deterrence by punishment.*”[14] Deterrence requires capability plus credibility coordination between all military and nonmilitary capabilities.

The contemporary and future battlespace is characterized by a sensor-saturated environment and intense electromagnetic warfare (EW) contestation. This dynamic is further complicated by the pervasive influence of space and cyber operations, which now have tangible effects on both strategic planning and tactical execution.

In such a contested ecosystem, deterrence and defence concepts must begin with a clearly articulated strategic objective and defined end state. As NATO doctrine asserts, credible deterrence requires convincing potential adversaries that the “*cost of aggression will be disproportionately high*”[8] rendering any attack not only futile but a grave strategic miscalculation. At the heart of this posture lies NATO's primary mission: the collective defence of its members, aimed at preserving the Alliance's territorial integrity, political sovereignty, and strategic stability.

To operationalize this mission, NATO doctrine delineates three interdependent core tasks: deterrence and defence, crisis prevention and management, and cooperative security. Each task is divided into sub-tasks, further translated into lines of effort and assigned to responsible commands, partners, or institutional entities. This structured operational design ensures that strategic intent cascades coherently into tactical implementation.

In today's increasingly unpredictable security environment, several critical trends in warfare have become evident.

First, the enduring value of surprise underscores a persistent strategic-operational dilemma. Despite the proliferation of sensors, satellite coverage, and intelligence platforms, the ability to anticipate an adversary's strategic intent or operational maneuver remains limited.

In the context of high-intensity, attritional warfare, volume of fire and the capacity to reconstitute combat power, remain decisive. However, less powerful actors may offset this asymmetry through enhanced speed and precision of fires, the application of network-centric warfare, and the adoption of mission command principles supported by resilient, flexible command-and-control (C2) systems.

“The use of adaptable emerging and disruptive technologies (EDTs) further amplifies this compensatory effect, enabling agile strike capabilities and dynamic battlefield adaptation.” [19]

Another crucial development is the compression of the decision cycle and the acceleration of the so-called *kill chain*. Forward-deployed sensors now enable real-time or near-real-time links with strike vectors, allowing for dynamic targeting within five minutes at the tactical level and approximately thirty minutes at the operational level. This responsiveness transforms sensor-to-shooter chains into tightly integrated decision ecosystems, vastly improving battlefield lethality.

Despite technological advancements, air superiority remains essential for campaign success. However, the mass deployment of drones is beginning to erode traditional airpower dominance. Evolving drone tactics are having a cascade effect on force structure, education, and training. These systems now operate at scale to generate mass effects, often in combination with traditional firepower platforms such as ballistic missiles, cruise missiles, artillery, and airstrikes. *“The next doctrinal evolution, swarm coordination, seeks to integrate these platforms into a unified, multi-vector attack model.”[2]*

Second, the roles of space and cyber domains have become foundational in shaping battlespace. These domains are not only integral to enabling real-time coordination and communications but also serve as decisive enablers for the effective employment of drones and other unmanned systems. Third, the autonomy of drones is advancing rapidly, reflecting a technological trajectory marked by shorter innovation cycles, algorithmic evolution, and adaptive mission parameters. *“Drones are increasingly capable of adjusting to dynamic operational conditions, making them indispensable tools in contemporary and future warfare.”[2]*

Terrain and critical infrastructure continue to shape the conduct of offensive and defensive operations, particularly in urban and key terrain environments. Drones are now proven assets in air, land, and maritime operations, offering cross-domain flexibility.

At the same time, population-centric effects and strategic communication remain central to contemporary conflict. Drone use has demonstrated not only kinetic efficiency but also significant psychological impact on civilian populations, blurring the boundary between battlefield and home front.

CONCLUSIONS

NATO must accelerate its pace of adaptation to remain relevant and operationally effective in a rapidly evolving strategic environment.

Emerging and Disruptive Technologies (EDTs) are no longer optional enhancements; they have become essential force multipliers that ensure both survivability and lethality across all domains.

To harness their potential, NATO must embrace a culture of innovation, backed by robust research and development (R&D) frameworks and a *“continuous exchange of information between institutional, industrial, and academic stakeholders.”[11]*

The development of common and collective capabilities is essential to fill systemic gaps that individual member states may be unable to resolve alone. Programs like *Global Hawk AGS* and *AWACS* exemplify the necessity and feasibility of multinational capability development.

Similarly, NATO’s operational success in the space and cyber domains hinges on deepening cooperation among Allies and synchronizing efforts with the European Union to accelerate the operationalization and integration of critical capabilities.

However, EDTs also introduce structural and doctrinal challenges. “*The emergence of new operational requirements, jointly defined by Allied Command Transformation (ACT) and Allied Command Operations (ACO), is already reshaping NATO's capability codes and radically influencing future capability targets and the “NATO Defence Planning Process (NDPP) cycle.”*”[1]

This transformation demands innovative force concepts, including hybrid force structures that integrate manned and unmanned elements, thereby necessitating fundamental force reform.

Revolutionary shifts are also expected in training, education, and exercises. Bold, adaptive exercises must provide safe environments to test, fail, learn, and refine, ensuring that tactical failures in simulations translate into operational success in combat.

NATO's modernization is ultimately a dual process: technological advancement and cognitive adaptation. In this context, innovation becomes not just a competitive edge, but a survival imperative. The modernization of NATO's guiding concepts, force structures, and deterrence mechanisms is indispensable for maintaining credible defence and strategic flexibility. This transformation encompasses both institutional reform and operational innovation at the tactical level.

In high-intensity, multi-domain warfare, survivability is not guaranteed by firepower alone but increasingly depends on deception-based measures, such as decoy operations, electromagnetic camouflage, and thermal signature suppression. These elements must be systematically integrated into Standard Operating Procedures to ensure force protection in environments saturated with ISR assets and exposed to advanced targeting systems.

The deliberate application of deception and concealment techniques, especially under electronic warfare and thermal surveillance, should no longer be treated as ad hoc improvisations but as core components of “*doctrinal planning and training exercises.*”[2]

No doubt the modernization of NATO forces is a priority, and addresses several areas, such as: readiness built up, interoperability, force digitization, connectivity and communications security, Cyber defence, expeditionary role, deep strikes integration, Joint Surveillance Targeting Acquisition Reconnaissance (JSTAR) integration at all operational levels, which further implies the necessary integration of modern UAS in operations, in parallel with standardization of counter UAS measures. [17]

The future of warfare will demand a force that can adapt rapidly or risk irrelevance and collapse in the face of exponential technological advancement. Emerging and Disruptive Technologies (EDTs), particularly those incorporating artificial intelligence, autonomy, and networked systems, are evolving at an unprecedented pace. These technologies are not simply tools—they are transformational enablers that will reshape the conduct of war.

Future battlefields will be dominated by systems capable of autonomous operation, mass employment, and multi-domain integration.

The proliferation of AI-enabled drone swarms, cyber-resilient UAVs, and precision-strike coordination mechanisms at both tactical and strategic levels will redefine operational tempo and command structures. Equally essential is the continuous stress-testing of autonomous systems in realistic, multi-domain training environments to ensure resilience, mission assurance, and interoperability under contested conditions.

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