THE FUTURE OF DRONES:

Strategic interregnum

Adapt Institute

EDITORIAL

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FOREWORD

Contemporary security debates often state that we live in a time of uncertainty, growing complexity and strategic deterioration. The usual prescription is similar: think more, spend more, innovate more. These imperatives rest on the assumption that we are witnessing a fundamental shift in warfare driven mainly by technology. Yet these assumptions are often overstated and not always supported by disciplined analysis.

Much of today's commentary on the future of war still lacks methodological rigor, misinterprets early battlefield lessons, or extrapolates isolated observations into broad forecasts, and in some cases even attempts to mask speculation as foresight. This risks misleading decision–makers precisely when choices on force design, capability development, and industrial policy require more clarity than any time before in the last two decades.

Fortunately, there is growing recognition of the limits of prediction and a renewed understanding of the value of structured futures thinking across the Euro–Atlantic community. Designed, bounded, and methodical foresight efforts are gaining ground and traction across NATO and national defence institutions. Their purpose is not to define what the future will be, but to assess the direction and extent of change across a volatile landscape shaped by technological, industrial, and operational dynamics. Work of this kind may well become increasingly essential for maintaining and improving the Alliance's deterrence and defence posture, both today and in the years ahead.

The Slovak Adapt Institute and the Facta Pro Futura team are one such contributor, and their work convincingly showcases the value and true utility of foresight, when applied to defence planning and hard problems in policy, planning and doctrines.

My engagement with their research began with their expert survey, which made it clear to me early on that this project represents a highly disciplined and scientific attempt, firmly based on foresight methods, to understand how unmanned systems influence defence today and tomorrow. Their work avoids technological determinism and places drones in their proper operational, organisational, and geopolitical context. They also apply a transparent foresight toolbox, like horizon scanning, a multi–stage Delphi process, and exploratory scenarios, to test key assumptions and examine plausible developments.

It is exactly this type of structured analysis that helps us recognise the broader moment we are in. The patterns emerging from their work, and from similar efforts across the Alliance, point to a transitional phase in which established assumptions are being challenged but, equally importantly, have not yet been fully overtaken by the rapid evolution and integration of unmanned systems.

Thus, we stand in a strategic interregnum. The doctrines of the past decades are increasingly strained by a reality defined not only by the presence of unmanned systems, but by their ubiquity, integration, and rapid evolution. Yet, their utility is not to be discarded entirely.

During my tenure as Head of Strategic Foresight at NATO Allied Command Transformation, I have witnessed how quickly theoretical debates about autonomy, mass, and software–defined capabilities translate into practical battlefield realities. The Russian war of aggression against Ukraine and contemporary conflicts in the Middle East are already providing answers to questions that, until recently, belonged mainly to wargames and seminars. Yet, the extent and direction of change remain a critical and unsolved problem, until we gather sufficient data, conduct more deliberate discussions and do more foresight efforts, like the current report to truly offer structured analysis of the systems and dynamics which shape the future of defence and deterrence.

The issues, challenges and opportunities showcased in the report carry serious implications. Building drone–integrated forces is not simply a matter of acquiring new hardware; it requires rethinking doctrine, logistics, industrial capacity, and adoption processes. The ability to field, adapt, and scale innovation faster than adversaries will increasingly determine military advantage. Looking toward 2030 and beyond, this analysis provides orientation and perspective. The future is not predetermined; it will emerge from the decisions taken now.

I commend this report as a valuable contribution to understanding the next drone age and the strategic choices that accompany it, while also proving the true utility of foresight to defence strategies.

Dr. Gergely Németh
Chief Executive Officer, Defence Innovation and Research Agency of Hungary
Former Head of Strategic Foresight, NATO Allied Command Transformation

EXECUTIVE SUMMARY

Living through highly dynamic and deeply transformative "second drone age"[1] makes strategic foresight an essential tool to **navigate through the fog of uncertainty**, a fog thickened by the ongoing and open–ended evolution of drone warfare, significantly accelerated mainly by the Russia–Ukraine war, and reinforced by conflicts across the Middle East.

Initial scoping and scanning phases identified core **assumptions**, **uncertainties** and **trends** that have been further tested throughout the research ***(see Chapters I and II)***. Based on the analysis of these elements, **FOUR CLUSTERS OF CHALLENGES** emerge that connect the present and future. The choices made in response to these challenges will significantly shape the next, "third drone age":

1. **FUTURE OF AIR DEFENCE:** Future air defence designs must integrate counter–drone capabilities and acknowledge that UAV threat is immensely broadening the challenge for secure airspace. Defence systems could blunt but will not necessarily erase drones. Layered counter–UAS reduces the threat, but volume, and continuous adaptation will get drones through. Interception success rates and cost exchange ratios should be closely tracked, analysed and assessed across different theatres. Patterns for "division of labour" between the military, other security services and private actors (critical infrastructure protection) with corresponding legal frameworks, organisational adjustments and technical equipment will be at the core of this challenge.

2. **ADAPTABILITY AT THE SPEED OF RELEVANCE:** A heavily EW–degraded environment, ever present ISR and compressed sensor–shooter loops have emerged as three most distinct impacts of mass–scale drone deployment. Their interaction creates a non–linear dynamic – the battlefield becomes more transparent, but not more manageable. Future capability requirements must ensure ability to fulfil goals while operating under heavy EW. Synergic effects stem neither from mass or sophistication but from overall integration, adaptability and systemic resilience. Speed becomes essential not only within sensor–shooter loops, but across the whole ecosystem, including innovation–to–deployment and procurement–production loops.

3. **UNMANNED WARFARE DIFFUSION:** The second drone age was ignited by the proliferation of small UAV into the hands of violent non–state actors. Meanwhile, the Russia–Ukraine war has demonstrated how UAV threats evolve, when mass, scale, and industrial resources are introduced. Innovations born on Ukrainian battlefields will diffuse globally by various means (state sponsorship, commercial, industrial espionage etc.). The character and scale of this "upgraded threat" coming from lone–wolf attackers, insurgents, organised crime, PMSCs and proxy actors, especially if combined with a foreign state patron, will shift power balances and seriously challenge internally unstable and weak states.

4. **INTEGRATION OF MILITARY–CIVILIAN–INDUSTRIAL COMPLEX:** Drones bring a new proposition to long–term debate over mass vs. precision: the availability of mass precision. Before operational and warfighting implications, deeper considerations of the capability development life cycle should take precedent. This includes resilient supply chains (ensuring supplies for critical time) and building the scientific, technical and engineering expertise. The mounting challenge of how to adjust procurement to fast innovation and as a follow–up what to stockpile, is already present. The key challenge is not just the scale but quality – what to produce, and how.

Responses to these challenges will generate changes that will define the character of the next drone age. These changes will be driven by disruptive forces resulting from, or responding to, drone adoption and the diffusion of drone–related technologies. This research has identified **FIVE DRIVERS OF CHANGE *(see Chapter III)*** that could significantly shape the future security environment and have a multidimensional impact across security, political and socio–economic domains:

1. **UNMANNED ASYMMETRY AMPLIFICATION** will shape power dynamics both between states and between states and non–state actors, as the democratisation of warfare brought about by drones gives smaller actors capabilities that were previously beyond their reach.

2. **ACCELERATED TECHNOLOGICAL EVOLUTION** will lie at the centre of the drone future, as drones continue to develop as a disruptive technology, raising not only significant technical and operational questions, but also ethical and legal ones.

3. **COUNTER–DRONE ARMS RACE** will be an inevitable response to the rapid pace of drone adoption and innovation, significantly impacting deterrence and defence postures.

4. **GEOPOLITICAL STRUGGLE** will introduce additional considerations into the strategic puzzle – supply chains, partnerships, and rules for the legitimate and proportional use of drones – will shape strategic geopolitical and geoeconomic choices.

5. **UNIVERSAL PROLIFERATION** will have both a quantitative and qualitative dimension and will fundamentally influence the strategic calculus of both state and non–state actors.

FOUR SCENARIOS *(see Chapter 4)* were developed based on the analysis of the change drivers and their mutual interactions. They explore alternative futures and provide descriptions of different plausible development trajectories. The actual shape of the future will likely emerge at the intersections of these scenarios and will, to varying degrees, contain elements of several of them.

1. **DEMOCRATISATION OF WARFARE** represents an expanded status quo, both in quantitative and qualitative dimensions, resulting in continuous low intensity conflicts and frequent, fragmented, and decentralised violence in both domestic and international contexts.

2. **UBIQUITOUS DRONE PRESENCE** represents incremental progress, resulting in a future that is not drone–dominated but drone–integrated. Drones become omnipresent tools of warfare and organic extensions of soldiers. Drone integration and interoperability provide advantage, but human judgment and accountability remain central.

3. **SOFTWARE DEFINED FUTURE** represents a transformative scenario, resulting in a changed mode of warfare defined by massive streams of data and AI–driven autonomy that augments and supplements human roles.

4. **POST–DRONE AGE** represents a wild–card alternative to a third drone age, or a follow–up in development, in which the disruptive potential of drones reaches its limits and drones are replaced by alternative technologies or become a routine, strategically exhausted element of warfare.

Finally, the report sought to answer two key research questions:

1. How will the development of the drone sector transform defence and security in the next decade?
2. What needs to be done to ensure that NATO maintains its strategic edge?

The final ***Chapter V: DRONE FUTURES*** provide answers to these two questions in the form of **strategic implications** and **recommendations**.

As drones remain a disruptive technology and we live in the digital age, technological advancements, software integration and data will remain the key drivers of drone adoption and development. However, beyond technological considerations, there are broader drone–related trends which will shape the security environment of NATO and introduce substantial political, societal and economic consequences. Five such areas with strategic implications were identified: **proliferation**, **democratisation**, **hyper hybridisation**, **deterrence erosion**, and **lowering the conflict threshold**.

Reflecting these strategic implications, the report recommends **revisiting the Alliance´s three core tasks** in light of recent developments. The report suggests rethinking the capability development life cycle, focusing on agility and adaptability, and integrating counter–UAS capabilities across the whole security system. On the international scene, addressing the likely increase of international instability, actively shaping international control regimes and norm building processes and extending the scope and focus of partnerships is suggested. To maintain the Alliance´s edge, iterative foresight is recommended.

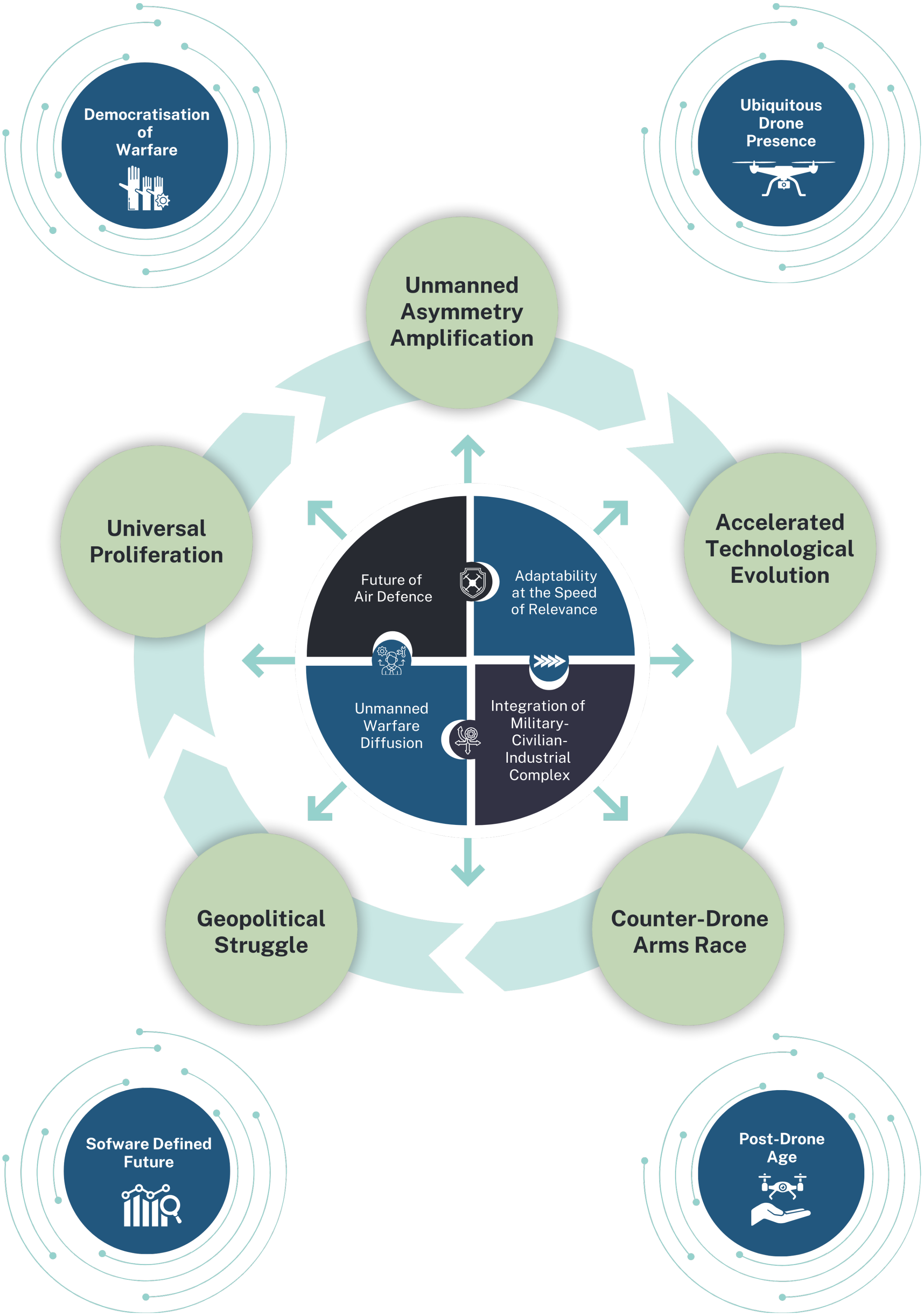


Figure 1: Challenges, change drivers and scenarios

STRATEGIC INTERREGNUM – BETWEEN DRONE AGES

During the last couple of years, especially since the Russian invasion of Ukraine, interest in unmanned aircraft systems (UAS) has skyrocketed globally. Drones have moved to the forefront of expert and public debates, not only regarding the Russo–Ukrainian war but also in discussions about the future of warfare. One common framing contrasts the revolutionary versus evolutionary impact of UAS on warfare.

Proponents of a drone revolution portray drones as "game–changers" or "silver bullets" against adversaries, and key components of defence. Sceptics disagree, arguing that drones can never be considered the primary determinant of victory.[2] While the debate, especially between experts and journalists, highlights differing views on the revolutionary potential of drone warfare, the lack of consensus among experts themselves reveals a far more nuanced picture than a simple expert–journalist divide.[3]

"To what extent can drones be the primary determinants of victory in warfare? This question is at the heart of the drone revolution debate in security studies."

James Wesley Hutto and James Patton Rogers

Drones have been shaping the character of warfare for quite some time. Their origins trace back to the mid–19th century,[4] with the first drones emerging in the early 20th century and later undergoing a series of evolutions punctuated by numerous setbacks.[5] It is, however, the recent mass proliferation of drone technology and its increased prominence in armed conflicts that brought them to the attention of both strategists and the broader public. Especially wars and conflicts across the MENA region and in Ukraine have shown how drones shifted from specialised and peripheral tools to ubiquitous and central elements of the modern international security landscape used by both states and non–state actors.[6] As drone technologies advance faster than doctrines or norms can adapt, understanding the implications of drone warfare has become a pressing necessity.

To avoid "reinventing the wheel", it is useful to embed the ongoing drones related discourse into the existing body of literature and research. Strategic realities of the 70s pushed the US to search for technological–doctrinal counter to Soviet conventional military overmatch. The second offset strategy was born, with focus on exploring the transformative potential of new technologies, especially in precision, stealth and sensing. In late 80s and early 90s, fruits of the second offset strategy were conceptualised under the **revolution in military affairs** (RMA) debate.[7] Direct siblings and in some cases offspring of the RMA is the cluster of related concepts such as network–centric warfare, reconnaissance–strike complex, information dominance, remote warfare or swarming.

Yet, it would be a mistake to employ a purely technological perspective. Overemphasising the technology aspect, while underplaying broader socio–political, or cultural drivers and enablers shaping the character of warfare in each era would narrow the assumptions we hold about the future.[8] Adoption and implementation of new technologies is neither universal nor uniform. In this context, the adoption–capacity theory offers a useful insight: the successful adoption of new technologies depends not only on financial resources but also on organizational adaptability. States that can effectively integrate emerging systems like drones into their doctrines and force structures are better positioned to shape the evolving balance of power, while those that fail to adapt risk strategic stagnation.[9]

For **NATO** and its member states, this challenge is highly relevant. Conflicts unfolding at the Alliance's borders demonstrate how drones are redefining contemporary battlefields. NATO's capacity to adjust to this new reality will shape not only its operational posture but also its credibility as a collective defence organisation in an era of rapid technological change.

"The Russian invasion of Ukraine has led to the first large–scale, high intensity war where both sides have extensively deployed military and commercial drones. What the conflict has so far highlighted is that the frequently mentioned 'game–changing effect' of drones on warfare depends on the game."

Dominika Kunertová

Ultimately, however, the "game–changing effect" of drones on warfare depends on the game.[10] In this respect, rather than focusing on revolution vs evolution, it seems more productive to analyse different "drone ages" to describe and compare the changing role and impact of drones in modern warfare.

If we define the **First Drone Age** as the post–September 11 world, with asymmetric warfare where there was a clear line between "drone haves and have nots" and the airpower remained the preserve of the world's more powerful states, the **Second Drone Age** is the one we experience nowadays, with the spread of weaponized commercial drones, and of state–manufactured military technologies to both states and non–state actors. Following this logic, the upcoming **Third drone age** may see unchecked and uncontrollable drone proliferation leading to fully autonomous systems becoming part of the non–state actor´s arsenal and bring about a reality of full spectrum drone warfare.[11]

What this next drone age looks like will depend on more than just technological considerations. The idea that warfare is primarily a matter of technology – or even a single technology – would likely prove incorrect in real–world circumstances.[12] One must always take into account non–linear developments, adversaries' reactions, the diffusion of technologies, and the inherent vulnerabilities that accompany new technologies, among other factors.[13]

This is where strategic foresight becomes useful. By applying a multidisciplinary approach and exploring alternative futures, it supports anticipatory decision–making. Dynamism has become a defining feature of our era — marked by volatility, uncertainty, complexity, and ambiguity — and the rapid evolution of emerging technologies will only intensify these conditions, rather than stabilize them.

Instead of offering predictions, strategic foresight provides a deeper understanding of potential developments and their implications. It supports efforts to address a fundamental strategic challenge: how to navigate uncertainty without losing control of events — and, ultimately, what this means for NATO.

Winston Churchill and the Secretary of State for War waiting to see the launch of a de Havilland Queen Bee radio-controlled target drone, 6 June 1941, Imperial War Museum via Wikimedia

METHODOLOGY

This report employed a strategic foresight methodology to explore the future of drones, with the aim of addressing two research questions:

- How will the development of the drone sector transform defence and security in the next decade?
- What needs to be done to ensure that NATO maintains its strategic edge?

The methodology followed the generic foresight process framework[14] and took inspiration from the OECD Strategic foresight toolkit[15] and the Horizons Foresight Method.[16]

PROCESS:

The scoping phase, including over 30 research interviews, was followed by a broad horizon scanning using the PESTLE framework. This input phase focused on identifying key assumptions, critical uncertainties and major trends.

The above elements were further tested and developed through the Delphi method. Delphi survey took place between June and September 2025 and included three rounds of questionnaires with a panel of 10 experts from 8 countries, both NATO and non–NATO, whose backgrounds covered a broad scope of expertise: governmental (domestic and international), military, non–governmental, academic, and business.

Following the input phase, several analytic techniques were applied (cross–impact analysis, cascading, futures wheel) to identify the most impactful change drivers and to develop four scenarios for exploring alternative futures.

To overcome the traditional tension between governance short–termism and the future–bias of futures studies, a novel approach was introduced – three analytical insights covering various types of conflict settings were used to test assumptions, uncertainties, trends, and to frame the drivers of change and scenarios under real–world conditions.

Throughout the process, participatory methods were used to elaborate on various aspects of the research:

- Expert Seminar in Bratislava, Slovakia, on 30 May 2025
- Webinar to conclude and evaluate the outcomes of the Delphi Survey, on 2 October 2025
- Workshop in Piešťany, Slovakia during the Drontex Conference, on 15 October 2025

Based on the research findings, the report identifies the strategic implications of drone adoption and the development of drone technologies for the security environment of NATO and formulates corresponding recommendations to ensure NATO´s strategic edge.

TERMINOLOGY:

This report uses the term **unmanned aircraft vehicle** (UAV) to refer to any aircraft operating or designed to operate autonomously or to be piloted remotely without a pilot on board, and an **unmanned aircraft system** (UAS) to denote an unmanned aircraft and the equipment to control it remotely. It uses these terms interchangeably with the term **'drone'**, which, for the purposes of this report, is treated as a broader concept that can also refer to other unmanned vehicles or systems operating in various environments, including on land, water, or underwater.

Chapter I – UNDERSTANDING THE PRESENT, NAVIGATING THE FUTURE

Initial scoping and scanning phases of the research resulted in the identification of several assumptions and uncertainties that shape the drone–affected security and defence landscape.

There is a widely held **assumption** that the growing drone adoption will usher in a new era of warfare, and the next decade will likely witness a large–scale development of unmanned systems (air, land, and sea). Artificial Intelligence (AI) adoption is believed to drive the next generation of disruptive drone operations, while simultaneously accelerating the pace of counter–drone responses. The robustness of communication infrastructure, technological breakthroughs, and active engagement with human resources and the private sector are seen as key enablers, while security of supply chains and availability of critical raw materials (CRM) remain possible major disruptors. The ability to speed up procurement, scale production and ensure the interoperability of drone and counter–drone systems among NATO members is considered essential for Allied security and defence. It is also widely believed that drones will remain broadly accessible, providing an asymmetric advantage to smaller nations and non–state actors.

Funding, regulation, geopolitical and geoeconomic developments are seen as the most critical **uncertainties**. Accelerated effort is needed in Europe to close technological and supply chain gaps. Two additional areas – the governance and administrative management of unmanned systems, and the public perception and social acceptance of drones – may at first appear more relevant to the civilian sector. However, with the anticipated rise in hybrid and other malign activities by state and non–state actors, these areas are likely to acquire growing significance within the defence and security domains as well. In this respect, the inherent vulnerabilities of drones need greater attention in addition to the dichotomy between drone threats and counter–drone measures.

To make these results more nuanced, the initial research was followed up by a **Delphi survey**.

Peter Schwartz in his *"The Art of the Long View"*,[17] while warning against overreliance on definitions, offers a tripod for building future scenarios. He defines predetermined elements, critical uncertainties and driving forces as the three basic elements of this effort.

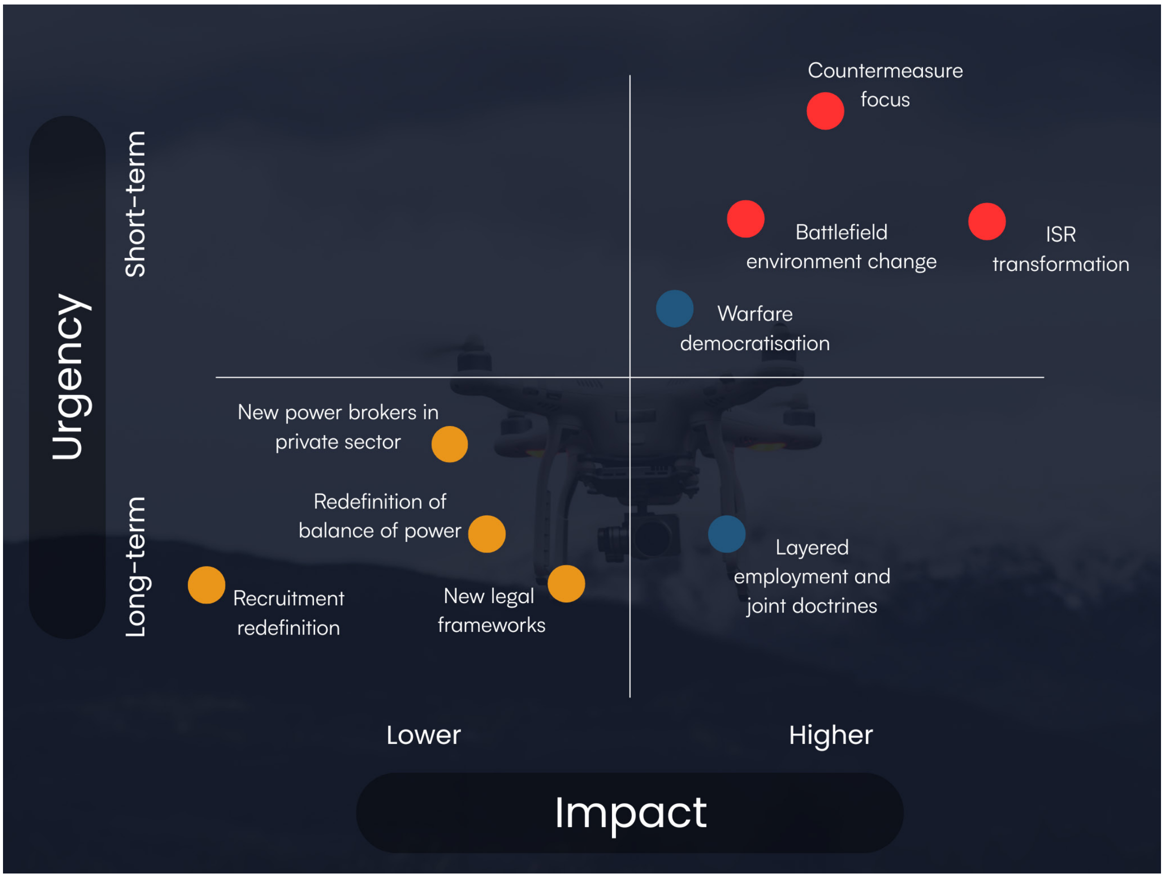
"Driving forces, predetermined elements and critical uncertainties give structure to our exploration of the future."

Peter Schwartz

The Delphi survey was built around these three elements and asked a panel of experts, with broad geographic as well as professional backgrounds, to respond to three questions aimed at identifying the key assumptions, critical uncertainties and key trends driving the change.

Two rounds of survey questionnaires served to shortlist the priorities and the third one to differentiate the key issues, based on urgency, capabilities, importance and impact.

The first question – "How will integration of unmanned systems redefine security and defence?" – served to specify the key ASSUMPTIONS:



Graph 1: Key Assumptions

The graph reflects the results of the third round of Delphi survey. The first two rounds resulted in shortlisting the key assumptions. In the third round experts evaluated the assumptions based on their impact (x–axis) and urgency (y–axis)

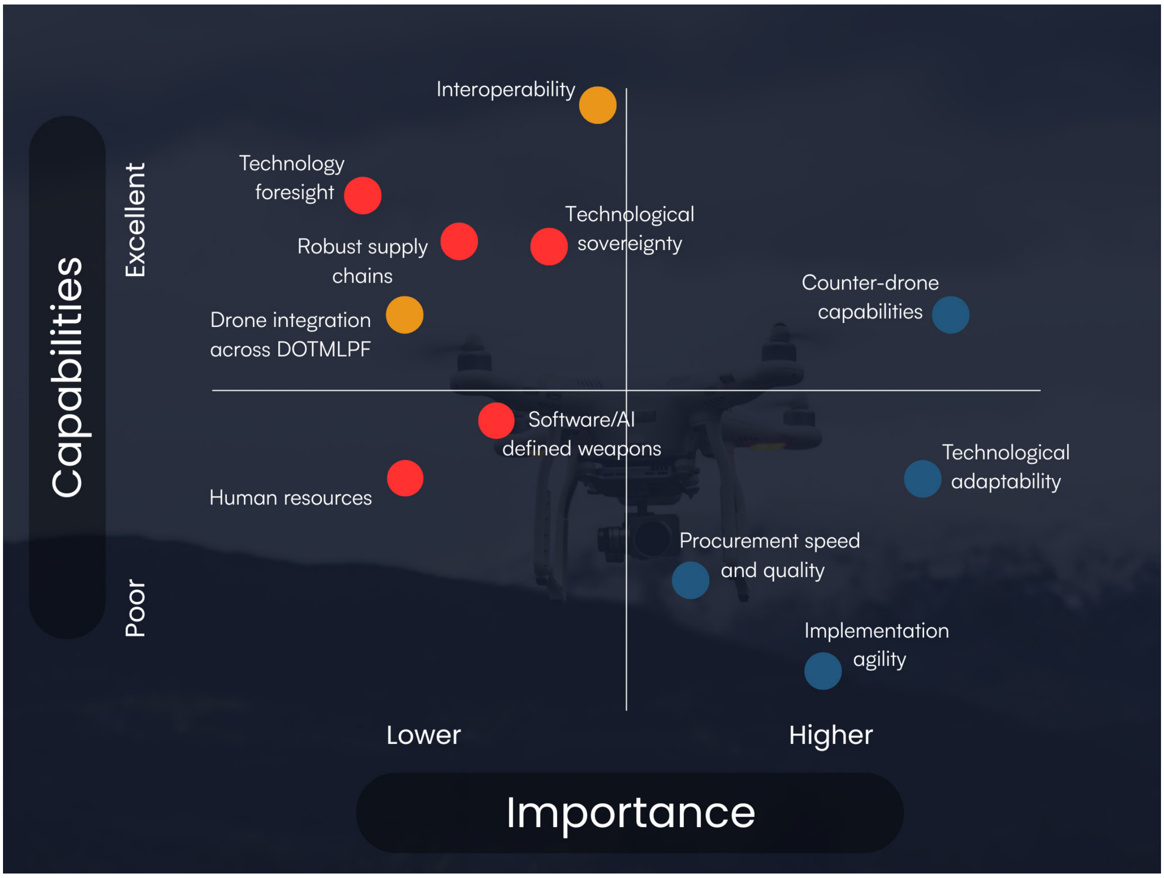
As the elements displayed in the graph had been shortlisted through the first two rounds of the Delphi survey, they all need to be considered **issues of high priority**. They can, however, be further divided into **three levels of strategic importance**.

CRITICAL ISSUES have both high urgency and high impact, thus requiring immediate attention. They define the ongoing drone age and include focus on drone **countermeasures**, **ISR transformation** due to radically increased real–time data management, and changes in the **battlefield environment** placing more focus on distributed, concealed and underground designs and requiring enhanced protection of expensive platforms.

SYSTEMIC ISSUES require a more nuanced understanding of their consequences and therefore may be considered slightly less urgent, but still highly impactful. Two developments stand out in the medium term. The first is **democratisation** of warfare, which will enhance the capabilities of smaller states and non–state actors in comparison to great powers, providing them with access to capabilities once reserved for major powers. The second is a gradual aggregation of UAS into **layered employment models** and creation of their own combined joint doctrines and wartime employment strategies.

STRATEGIC ISSUES could define the next drone age and will require longer–term attention and strategic reforms. Development could lead to possible regional **shifts in the balance of power**, as drones may provide technologically advanced nations an overmatch over numerically superior but technologically inferior states. UAS can also catalyse the rise of a new defence manufacturing ecosystem with **new power brokers in the private sector** that may challenge the dominance of traditional defence primes, which historically focused on exquisite, high–cost systems. Human resources management may also change, as the right **recruitment** will replace mass conscription. UAS will reduce dependence on large manpower pools while altering the profile of required personnel towards tech–savvy, skilled operators. Last but not least, automation and autonomy will challenge domestic and international **legal frameworks** guiding the permissible use of force and responsibility for illegal acts in combat.

The second question – "What will differentiate winners from losers in this technological arms race?" – focused on UNCERTAINTIES:



Graph 2: *Uncertainties*

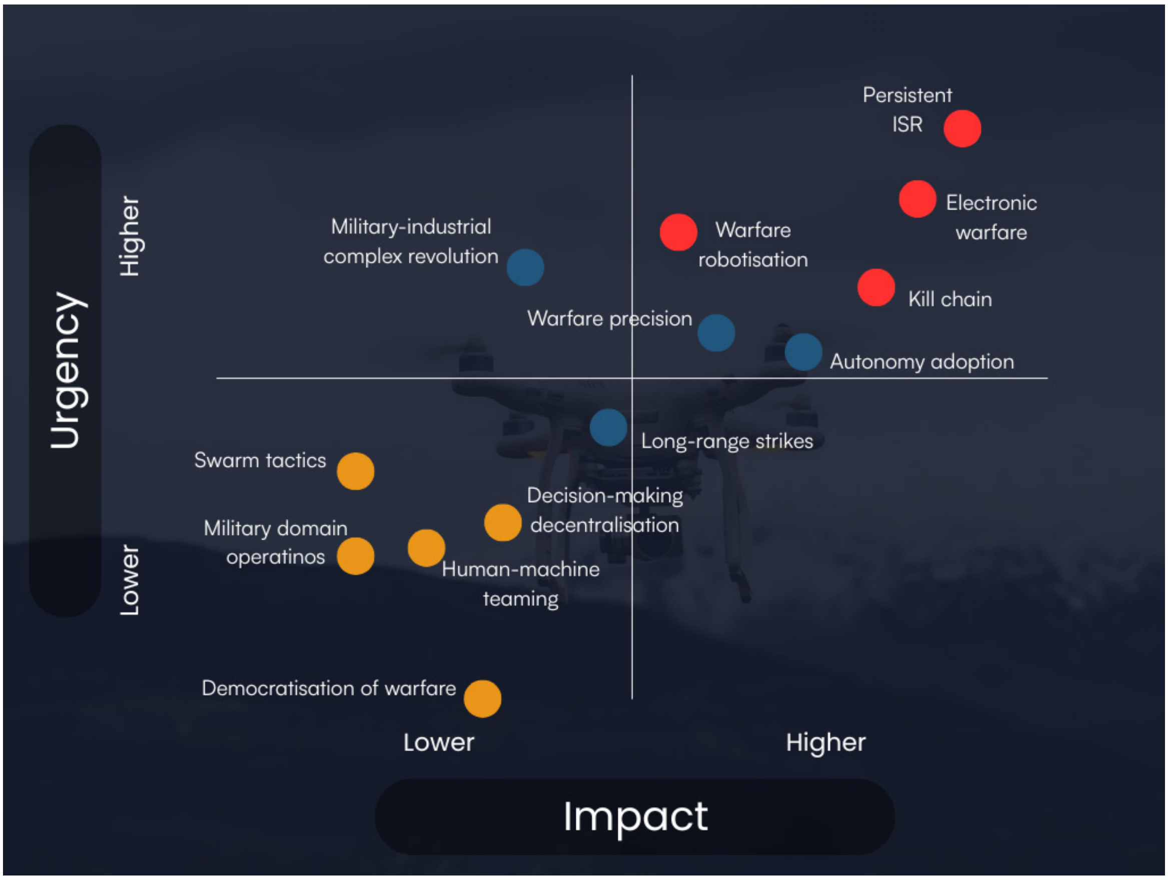
The graph reflects the results of the third round of the Delphi survey. The first two rounds resulted in shortlisting the key uncertainties. In the third round experts evaluated these uncertainties based on their importance (x–axis) and NATO capabilities in the respective area (y–axis).

CRITICAL GAPS refer to areas of high importance and low capabilities. Future dynamics will be largely determined by mutually interdependent development of **drone and counter drone capabilities** at the speed of relevance. The **ability to adapt** technology quickly to the changing environment, and to execute rapid measure–countermeasure cycles, will have both technological and administrative or political aspects, particularly in a multilateral setting such as NATO. In the longer term, **efficient procurement** will need to reflect not just speed and flexibility, but also quality, in order to achieve the state of the art in dramatically accelerated innovation cycles, to prevent adoption of unsafe systems, and to avoid falling for the drone hype. To succeed, this effort will need to go hand in hand with an **agile approach to implementation** of new technologies (R&D –> production –> fielding cycle), including flexible certification, sandboxing, public–private accelerators, and rapid operationalization of commercial off–the–shelf (COTS) technologies within a coherent Allied framework.

STRATEGIC ENABLERS: The second group of uncertainties represent strategic enablers to ensure NATO´s technological edge. They include the will to invest into **human resources** – educate, retain, and leverage top–tier engineering talent and ability to attract talent from the civilian sector and abroad to ensure strategic edge in the development of sophisticated **software–defined weapons**, in particular leadership in AI and autonomy. This needs to be supported by robust **supply chains** of critical components and CRM, or development of own resources, ultimately leading to achievement of **technological and operational sovereignty**. Effective responses in these areas could be further accelerated by cultivating **technology foresight** capabilities to assess trends, monitor and detect emerging technologies, asses their impact and possible applications.

SYSTEMIC CHALLENGES: Two elements can be singled out further, as they relate to drone adoption across NATO forces and thus will represent systemic challenges to NATO operations. First, the ability of NATO member states to integrate drones along the **entire DOTMLPF** (doctrine, organization, training, material, leadership and education, personnel, and facilities) will require the development of new combined arms doctrines and the formation of multi–layered fleets. Second, **interoperability** across forces will be needed both among the diverse manned and unmanned systems and platforms within armed forces, and among different UAS and CUAS types and layers across allied forces.

The third question – "Which elements will drive the change regarding the future of security and defence?" – explored the expected key TRENDS:



***Graph 3:** Trends*

The graph reflects the results of the third round of the Delphi survey. The first two rounds resulted in shortlisting the key trends. In the third round, experts evaluated these most important trends based on their impact (x–axis) and urgency (x–axis).

Based on the interplay of impact and urgency, we can categorise priorities in **three clusters**:

OPERATIONAL IMPERATIVES describe a battlespace that becomes unprecedentedly transparent (everyone sees everything), but also contested (denial, deception, jamming). **Persistent ISR** increases situational awareness and leads to **fast kill chains**. Rapid reconnaissance accelerates targeting, decision–making, and strike processes, employing ISR drones in combination with artillery, strike drones, or loitering munitions. In turn, this increases the need for deception, masking, and countermeasures. **Electronic warfare** (EW) will force doctrines to emphasize resilience, autonomy, and decentralized command and control (C2). **Robotization of warfare** will redefine force projection and readiness through forward deployed, stand–by unmanned capabilities.

STRUCTURAL TRANSFORMERS describe a deeper strategic evolution. Increased battlefield transparency and loitering capabilities enhance **warfare precision and lethality**. Proliferation of **long–range strikes** blur the distinction between frontlines and strategic depth. **Autonomy adoption** will require doctrinal revisions regarding command authority, decision–making, rules of engagement, responsibility, and accountability. **Transformation of the military–industrial complex** will occur as the acceleration of the innovation–production–deployment cycle drives closer integration between the armed forces and the defence industry, enabling faster adaptation and frequent updates of weapon systems.

ASYMMETRIC DISRUPTORS describe emerging asymmetries and disruptions that could challenge traditional power dynamics and force structures. The **democratisation of warfare** enables smaller actors to use drones to close capability gaps with larger states and achieve technological advances despite limited resources. Drones can partially supplement human forces, compensating for demographic decline and necessitating greater robotic integration and **human–machine teaming**. Employment of **drone swarms** alter battlefield engagements and redefine doctrinal tenets, especially for air defence and air superiority. **Decentralisation of initiative and decision–making** will likely take place providing greater responsibility to middle–level and junior commanders and shift towards **multi–domain operations** (MDO) integrating all domains (maritime, land, air, space, cyberspace) and dimensions (physical, virtual, cognitive). Yet, the clash of these two trends – decentralisation vs MDO – can also generate another layer of complexity to future operations.

Chapter II – THREE THEATRES

To overcome the traditional strategic foresight short–termism vs future–bias dilemma, this report introduces three analytical insights to test assumptions, uncertainties, and trends in real–world conditions. We selected one recent and two ongoing armed conflicts in which drones were or continue to be playing a significant role. Yet, all three represent distinctive cases with different variables in play.

The Second Nagorno–Karabakh war is an example of an inter–state war, where drones were deployed by an actor with both quantitative and qualitative overmatch. UAVs served as an enabler of sensor–shooter compression leading to offensive dominance and quick, decisive military victory for Azerbaijan.

The ongoing **Russia–Ukraine** war is another case of inter–state war, yet the use of drones is relatively symmetric. Both sides deploy unmanned systems with success on tactical and operational levels, and the war serves as a laboratory and accelerator of unmanned warfare.

The cluster of **Middle East** conflicts showcases a mixture of non–state (various local militias, insurgents and terrorists), quasi–state (Hezbollah or Houthis), and state actors (Israel, Iran and Turkey) engaged simultaneously in counterterrorism and counterinsurgency and high–end and intensive conventional military operations. Capabilities present in the theatre scale from rudimentary, and commercial off–the–shelf (COTS) based to advanced high–tech and everything in between.

Key Observations:

1. **HIDER–FINDER DYNAMICS:** Layered, integrated counter–UAS capabilities can blunt, but not erase, drones as a threat. Through massing volume and adaptive employment, drones will get through – especially against unprepared or thinly layered defences. Yet, low penetration rates might be balanced by the cost–imposition effect. Therefore, cost–exchange–rate trends – drone vs interceptor vs EW – across theatres need to be analysed and assessed carefully.

2. **INTEGRATION AND ADAPTABILITY:** Effective force employment and advantage on the battlefield stems neither from mass nor sophistication of deployed platforms alone, but from overall integration and adaptability. This applies to immediate warfighting as well as to logistics, procurement and manufacturing. Sequencing and speed are of the essence from the procurement–production cycle, and innovation–deployment cycle to targeting–decision–action cycle on the battlefield.

3. **DOMINANCE UNDER ELECTRONIC WARFARE (EW):** EW is equally impactful as the presence of drones on the contemporary battlefield. Unmanned and EW operations are evolving in a co–dependent manner. Dominance in the EW–degraded environment depends on integrating offensive capabilities with protective measures, deceit, resilient comms, and emission discipline.

4. **PSYCHOLOGICAL AND INFLUENCE EFFECTS:** Drone imagery repeatedly proves to be a powerful strategic tool shaping perceptions of both domestic and foreign audiences and significantly contributing to overall political goals. On the tactical level, drones' omnipresence generates fear, anxiety and paralysis equally among soldiers and civilians. UAVs also enable documentation of adversary actions including war crimes. Integrating cognitive and psychological dimensions of drone use into their employment doctrines unlock additional potential.

5. **INTERNATIONAL PARTNERSHIP MATTERS:** States with allies or partners able to provide weapon designs, critical components, technology transfer, manufacturing and logistics bases prior or at the beginning of conflict hold initial advantage over their adversaries. In later phases, the ability to "naturalise" foreign designs, establish supply chains and ensure domestic production is key.

NAGORNO–KARABAKH WAR

Summary: Viewed together, the 2020 Nagorno–Karabakh war and Turkish operations in Idlib and Libya show that decisive advantage comes from tightly integrating unmanned aircraft, precision fires, electronic warfare, and fast sensor-to-shooter command networks. Azerbaijan's overall dominance was effectively leveraged by a drone-artillery kill chain, which neutralized Armenian air defences and armour. The Nagorno–Karabakh war can be seen as a conflict where two generations of warfare met. The newer, drone–enabled Azerbaijani model proved clearly dominant over the older Armenian model with virtually no drones–based capabilities. Such conditions might be hard to replicate as UAS and CUAS are now understood as key components of modern warfare.

The Nagorno–Karabakh War in late 2020, alongside Turkish military operations in Idlib and Libya in the same year, represents a good case for understanding the evolving character of modern warfare, emphasizing critical shifts in doctrine, technological integration, and strategic execution. These conflicts collectively underscore the escalating significance of UAVs, precision artillery, and electronic warfare, which are reshaping future battleground dynamics and challenge established military paradigms.

Azerbaijan entered the Nagorno–Karabakh War with clear advantages: 70,000 active troops, 300,000 reservists, and a 2019 defence budget of USD 1.8 bn. Its inventory included 450 tanks, 900 armoured vehicles, 600 artillery systems, Israeli LORA missiles, and a diverse fleet of drones. By contrast, Armenia fielded 44,800 troops, 210,000 reservists, and a USD 644 mil. budget, relying on aging Soviet–origin systems. Forces in Nagorno–Karabakh represented 20,000 personnel and 200–300 T–72 tanks.

Drone–Artillery Kill Chains

The war ended in a decisive Azerbaijani victory. Armenia lost over 250 tanks, 160 vehicles, 300 artillery systems, 20 radars, and about 5,000 personnel (10% of force).[18] Azerbaijan reported 3,000 losses and under 60 tanks destroyed. These figures underscore the effectiveness of Azerbaijan's drone–artillery synergy and the weakness of static formations without integrated defences. Bayraktar TB2s armed with smart micro munitions, supported by Israeli kamikaze drones (Harop, Orbiter, SkyStriker), conducted a successful Destruction of Enemy Air Defence (DEAD) campaign. Armenian systems were neutralized early, enabling sustained strikes on mechanized and artillery units. Innovative deception included using obsolete An–2 aircraft as decoys to expose surface–to–air radars (SAM), mirroring Israel's 1982 Lebanon tactics.[19]

PLATFORM	ORIGIN	ROLE	ARMAMENT	KEY ACHIEVEMENTS
Bayraktar TB2	Turkey	ISR / Precision strike	MAM-L/C	Primary platform in time-critical air strike campaign
Harop	Israel	Loitering munition	Explosive warhead	Targeted radars & SAMs
SkyStriker	Israel	Loitering munition	Explosive warhead	Complemented TB2 strikes and artillery
Orbiter-1K	Israel	Loitering munition	Explosive warhead	Complemented TB2 strikes and artillery
An-2 Decoy Aircraft	Azerbaijan	Deception	None	Drew out SAM radar emissions

Table 1: Major drone systems used in Nagorno–Karabakh War

The pattern extended to other theatres. **In Libya**, Turkish TB2s shifted momentum in favour of the UN–recognized government by destroying Pantsir S1 air defence systems and disrupting supply lines. **In Idlib**, Turkish Anka–S and TB2s acted as "mobile airborne artillery," employing smart micro munition bombs for precise strikes in densely populated zones. Together, these cases raise questions about the **survivability of heavy armour**, given the scale of losses inflicted by drones,[20] and emphasize the importance of **integrating sensors**, **C2**, **and precision fire** – core tenets of network–centric warfare. Turkey's Operation Spring Shield demonstrated this integration, with systems like TAFICS (integrated communication system) and ADOP–2000 (C4I fire management system) enabling real–time sensor–to–shooter cycles.

EW also played a decisive role. Turkish Koral and REDET systems (both land–based EW platforms) disrupted enemy radar and communications while emission control measures protected friendly assets. These developments confirm several trends: mass proliferation of drones, their democratisation through cheap domestic production, and their role in hybrid threat environments where attack and surveillance converge.[21]

The **cost–effectiveness of drones over manned fighters** became evident, as Turkey could absorb UCAV losses that would be catastrophic with jets. Social media emerged as an auxiliary battlespace. Both Armenia and Azerbaijan conducted online propaganda, but Azerbaijan's dissemination of drone footage secured psychological advantage, boosting morale and undermining Armenian credibility abroad.[22]

Key Lessons:

The presented case suggests that drones are **not a temporary asset** but an emerging pillar of modern warfare. There are **three major shifts** behind this transformation. First, a shift toward cheap, mass–produced, multi–role platforms capable of ISR and precision strike. Second, the fusion of propaganda and combat, with real–time imagery shaping battlefield psychology and international legitimacy. Third, the emphasis on rapid, intelligence–driven targeting, where human, electronic, and UAV inputs converge to eliminate high–value assets.

Future development should **prioritize resilient guidance** for artillery, adaptable platforms capable of switching missions, and **resilience against EW**. Overall, the Nagorno–Karabakh War demonstrates a transformation: effectiveness stems not from force size or heavy platforms but from integration, adaptability, and the ability to operate simultaneously in physical, electronic, and informational domains.

DOCTRINE ELEMENT	LEGACY FORCE STRUCTURE	DRONE-INTEGRATED FORCE STRUCTURE	OBSERVED EFFECT
Air defense integration	Static, fragmented	Networked, dynamic	Rapid suppression of AD assets
C4ISR	Limited	Real-time, digitally integrated	Accelerated kill chain
Counter-EW	Reactive	Offensive + protective	Effective jamming and emission control
Public information ops	Defensive	Offensive, coordinated with combat	Psychological and informational dominance

Table 2: *Doctrinal comparison of Armenian legacy force and Azerbaijan drone-integrated force structure*

In conclusion, the 2020 Nagorno–Karabakh War, alongside Turkish operations in Idlib and Libya, demonstrates that the **decisive edge in modern conflict lies not in the mass of legacy platforms but in the ability to integrate unmanned systems, precision fires, and electronic warfare into coherent operational frameworks**. These cases show that adaptability, resilience, and information dominance increasingly shape outcomes on the battlefield, underscoring a broader transformation of warfare toward multi–domain, intelligence–driven, and network–enabled operations.

On the road north of Stepanakert in Nagorno-Karabakh, military equipment returning from the front following reports of of "kamikaze" drones operating in the area around the destroyed city of Agdam. Source: Clay Gillard via Wikimedia Commons

RUSSIA–UKRAINE WAR

Summary: At the outset of the full-scale war, Russia fielded more drones but lacked the networked command-and-strike architecture that Ukraine rapidly built around Bayraktar TB2s to compress the sensor-decision-strike "kill chain." Since 2022, both sides have transformed: Ukraine has leveraged a nimble public-private ecosystem to scale FPV and long-range systems, built Unmanned Systems Forces, and institutionalized drone-centric C2, while pioneering maritime drones that reshaped the Black Sea battlespace. Russia, drawing on earlier Israeli-derived know-how and prewar designs, has converted its industrial base to mass-produce Shaheds and fiber–optic-guided drones, yet still trails in organizational and doctrinal integration. The conflict also shows a transparent, EW–contested battlefield where armour without unmanned/EW protection is highly vulnerable.

On the eve of the full–scale invasion, the Russian Armed Forces already possessed a developed drone component. By contrast, Ukraine was only beginning to take its first steps in this domain. The only significant advantage Ukraine held at that stage was the acquisition of Turkish–made Bayraktar TB2 strike UAVs.

It was these drones that enabled the Armed Forces of **Ukraine to apply a network–centric, asymmetric approach that contrasted sharply with Russia's traditional, linear doctrinal thinking**. Leveraging the Bayraktars, Ukraine was able to accelerate the decision–action cycle. The capability of Bayraktar TB2 to conduct ISR, acquire target coordinates, relay data to a command node, and independently engage targets in real time gave Ukrainian forces a critical advantage. At that time, the Russian military lacked such integrated capabilities and continued to rely on massed fires from artillery and legacy systems.

In February 2022, Russia fielded a significantly larger drone fleet than Ukraine. However, Russian UAVs were not networked into a unified command–and–strike architecture. This **lack of integration** severely delayed their targeting and engagement loops, reducing their operational effectiveness on the battlefield.

Since then, both Ukraine and Russia have undergone a **rapid technological transformation** that has largely **equalized their respective drone capabilities**.

Ukraine's comparative strength lies in its **agility**, **battlefield–driven innovation**, and the ability of private enterprises to rapidly design, test, and deploy new systems tailored to operational demands. However, the key vulnerability remains the **inertia of state institutions** in scaling these innovations for broader military adoption.

Conversely, **Russia** suffers from a **weak private sector** that **limits creative solutions** and bottom–up innovation. Yet its strength lies in the **ability to mass–produce** select capabilities once they are adopted into the military system. The most illustrative examples are the industrial–scale production of Iranian–origin Shahed drones – reportedly reaching 180 units per day as of August 2025 – and Russia's lead in producing fibre–optic–guided drones with enhanced resistance to electronic warfare.

Russia's Drone Arsenal Before 2022

More than a decade before the full–scale invasion of Ukraine, Moscow recognized the potential of UAS, particularly following the critical problems with ISR during the 2008 war against Georgia. In 2010, the Russian defence ministry signed licensing agreements with Israel Aerospace Industries, allowing the assembly of the Searcher II (branded Forpost in Russia) and the smaller Bird Eye–400 (renamed Zastava).[23] Gaining access to Israeli technologies enabled Russia to start developing various indigenous platforms. Although large scale deployment began after 2022, the groundwork – including factory lines and operator training – was established earlier.

Russian kamikaze drone and sappers of Ukrainian police.
Source: npu.gov.ua via Wikimedia Commons

SYSTEM / FAMILY	TYPE	ORIGIN / MANUFACTURER	RANGE	PRODUCTION / SERVICE TIMELINE	ROLE / NOTES
Forpost/ Searcher II	Reconnaissance UAV	Israel Aerospace Industries – licensed in Russia	250 km	Licensing/assembly agreement signed 2010	Early Israeli import helped Russia master UAV design & production
Zastava/ Bird Eye 400)	Small tactical UAV	Israel Aerospace Industries – licensed in Russia	10 km	Licensing/assembly agreement signed 2010	Smaller imported platform used to build domestic capability
Orlan-10	Reconnaissance UAV	Special Technology Center – Russia, parts sourced internationally	600 km	Serial production from early 2010s	Principal reconnaissance drone for artillery and other units
Granat / Eleron / Takhion (families)	Short-range reconnaissance UAVs	Various – Russia	15–50 km	Integrated across brigades & divisions (timeline: early 2010s / ongoing)	Cover shorter ranges; used at brigade/division level
Kub-BLA / Lancet	Loitering munitions (strike drones)	Kalashnikov/ZALA Aero Group – Russia	40 km	Unveiled 2019; large-scale deployment began after 2022	Loitering munitions – deployment ramped up after 2022
Shahed/ Geran (families)	Strike / loitering munition	HESA- Iran produced in Russia at scale after adoption	2,500 km	Large-scale programs launched after start of large-scale aggression (ongoing)	Strike drone mass scaled up in Russia

Table 3: *Russian military UAV fleet in 2022*

After the aggression against Ukraine in 2022, Russia launched several programs to scale up reconnaissance and strike drones of various types, including the Iranian Shahed. According to Ukrainian media quoting sources in the Ukrainian Defence Intelligence (GUR), as of the end of June 2025, Russia could produce about 170 Shahed drones per day, with the prospect of increasing the number to around 190 per day. On an annual basis, this means more than 69,000 strike drones with a range of up to 2,500 km.[24]

Technologically, Russian developments are not better or more advanced than Ukrainian ones. However, the ability to quickly scale up and increase production creates significant problems for the Armed Forces of Ukraine both on the front line and in the rear. At the same time, **Russia**, despite its clear resource advantage, **has not been able to catch up with Ukraine at the organizational or structural level**. Russia has not created a separate branch of the armed forces dedicated to unmanned systems and is lagging behind in the field of naval and land drones as well as doctrinally. This gives the Armed Forces of Ukraine an advantage on the battlefield.

Ukraine's Drones Capabilities: From Near Zero to Drone Centric Warfare

When Russia first attacked Ukraine in 2014, the Ukrainian Armed Forces had virtually no operational UAV. The few Soviet era reconnaissance drones were obsolete. After 2014, Ukrainian private companies began to develop small reconnaissance platforms such as the Furia[25], PD–1[26], Skif[27] and Leleka–100. But the adoption process was inefficient and overly bureaucratic. Persistent **bureaucratic hurdles and limited funding** meant Ukrainian units relied on **volunteer donations and ad–hoc purchases**. The domestic drone industry remained small and fragmented up to 2021.

In 2018, Ukraine purchased a small number of Turkish Bayraktar TB2 UCAVs.[28] These drones were not used offensively until 26 October 2021, when a TB2 destroyed a Russian D30 howitzer. The drone used a precision–guided munition and stayed on its own side of the line of contact.[29] This engagement, widely viewed as a turning point, demonstrated the potential of pairing UAS with precision weapons and highlighted the **need for a network–centric "kill chain".**

Russia's full–scale invasion in 2022 triggered a fundamental shift. Ukraine mobilised its tech sector, deregulated procurement and Ukraine's armed forces have embraced a **network–centric, drone–first doctrine**. Every kill chain begins with unmanned eyes on target, relaying the coordinates via battlefield management systems like Delta[30], and ends with a drone delivering precision munitions. The aim is to **compress decision loops and deny the enemy any safe manoeuvre space**.

Ukraine's **drone renaissance is rooted in civil society**: volunteers, private firms and grassroots funding drove innovation after 2014. Since February 2022 this ecosystem has exploded. In 2024 alone, Ukraine reportedly manufactured over 2.2 million FPV drones and more than 100,000 long–range strike drones (some capable of strikes up to 1,700 km).[31] Drones now account for most battlefield strikes. Ukraine plans to deploy about 30,000 long–range drones[32] and continues to prioritise FPV models, including tethered fibre–optic variants.

Late 2022 saw the creation of UAV strike companies within combat brigades, quickly followed by entire battalions and brigades of drones. In June 2024, Ukraine created a separate **Unmanned Systems Forces** to write doctrine, train operators and conduct deep strike operations.[33] Mechanised **brigade commanders now have direct authority and funding to procure** drones and electronic warfare kits, bypassing previous bureaucratic bottlenecks.[34] The **"Drone Line"**[35] concept envisages a **up to 20 km kill zone** of continuous unmanned overwatch and pre–emptive strikes.

At sea, Ukraine's sea drones have imposed a new anti–access (A2) bubble over the Black Sea. Ukrainian drones and long–range munitions have destroyed or forced the retreat of roughly a third of Russia's Black Sea Fleet[36] and **overturned 20th century assumptions about naval warfare**, demonstrating that swarming sea drones can neutralise capital ships.

Defining Features of Combat Operations

Technologies influence the tactics of units, while the eternal hider–seeker competition constantly generates new opportunities that give an advantage on the battlefield: new drone systems, AI systems, massive use of strike drones, and the rapid development of interceptor drones. In addition, Russia has adapted its tactics of small assault groups with unmanned systems. This has led to an increase in casualties, yet it has allowed the Russian army to continue its creeping offensive for a year and a half in a row.

- Tens of thousands of drones and sensors have formed an **up to 20 km "kill zone"** characterised by high transparency. Every heat signature, radio signal, or unnecessary movement triggers an immediate response with high probability of elimination.
- Traditional 20th century designed **armoured vehicles or infantry columns become critically vulnerable** without the protection of EW systems and unmanned platforms. Armoured vehicles themselves are gradually giving way to unmanned combat vehicles that perform logistical, transport, reconnaissance, and combat tasks (including fire support and breaking through enemy defences), as well as the more traditional task of clearing routes and territories of mines.
- To stimulate the overall adaptation cycle Ukraine has introduced the **Unmanned Systems Forces**, a corps–based command structure, and launched a **Brave1 Market**[37] where units "buy" equipment with electronic points (ePoints)[38] earned from confirmed target kills.

Victory in the current war, and in any future high–tech conflict, **will hinge on how quickly a nation can move innovations** from the lab through production **to battlefield use**.

Key Lessons:

Russia's war against Ukraine is a **convergence** of technology, industrial progress, and command architecture that together determine the operational and tactical results of combat operations. AI, "spectrum manoeuvring," and rapid production upgrades are replacing "mass" as the key factor in high–intensity warfare. Whoever can shorten the cycle from science to production and application will dominate the next war. In other words, it is not only the **speed of the tactical cycle of "sensor–decision–strike"** but also the **cycle of "R&D – production scaling – application"** that is decisive for dominance in modern warfare.

Priority Areas:

- Edge **AI** to merge intelligence, planning and fire–control into semi–autonomous systems with a drone–centric approach.
- Advanced **EW** and cognitive–radio networks that create a secure digital field and deny the same to the enemy.
- **Cheap**, **long–range**, **precision** unmanned systems – **air**, **ground** and **maritime** – to strike infrastructure, exhaust air defences and conduct coordinated mass attacks.
- **Large–volume** drone production (strike, ISR, air–defence, multi–domain robots) to spend machines, not soldiers.
- Exploitation of dual–use technology – commercial satellites, 3–D printing, encrypted messengers, COTS EW kits and cloud services, to give small actors asymmetric leverage.

A nation that first executes a full transition to this new military–technological order will gain significant advantage; the side that lags will struggle with unsustainable levels of attrition, which now targets the opponent's entire military–economic base. Ukraine's rapid restructuring shows that such adaptation is possible.

MIDDLE EAST CONFLICTS

Summary: Drones in the Middle East have democratized warfare, enabling both states and non–state actors to field effective capabilities. Israel, Turkey, and Iran are the leading state developers: Israel is a technological leader with extensive experience in seamless integration of drones for surveillance and precision strikes. Turkey has built a strong domestic industry with combat–proven exports like the Bayraktar. Iran produces cheaper, less sophisticated systems but at scale, using them and transferring them to proxies like Houthis or Hizballah. These systems prove capable of disruptive results against Saudi Arabia, the UAE, shipping, and Israel, though Israel's layered air defences have blunted much of the damage. At the same time, COTS quadcopters remain the most widespread and effective option for less–sophisticated actors, as seen in Syria. Overall, drones have reshaped MENA battlefields by empowering weaker groups while also showing that integrated defences can contain their effects, leaving future warfare defined by both cheap disruptive systems and advanced counter–drone environments.

In the **Middle East**, drones have served as a **major driver of the democratisation of warfare**. The region is unique in that it includes state actors with sophisticated drone capabilities alongside non–state actors who have developed advanced operational practices, and non–state actors with unsophisticated drone capabilities who have nevertheless been able to use these capabilities effectively.

Israel, **Iran**, and **Turkey** are global leaders in the development and use of drone technology. **Hizballah** in Lebanon and the **Houthis** in Yemen have become very adept non–state users of drone technology, with capabilities exceeding even those of many sophisticated, modern militaries. **Rebel groups in Syria**, in their fight against the Assad regime, have been able to use drone technology, though they lack sophisticated capabilities and rely primarily on rudimentary drone equipment.

Israel: Industrial Leadership & Operational Integration

Israel is a global leader in developing UAS, with several companies developing systems considered to be cutting–edge in the global drone market. Perhaps even more importantly, Israel has been a leader in developing tactics, techniques, and procedures for the employment of UAS in the real–world battlefield and for integrating unmanned systems with other components of the military. The Israeli Air Force reportedly uses 100 different types of drones and drone flights made up 70% of total Air Force flight hours in 2019.[39]

Israel has long used UAS for persistent surveillance of the Occupied Palestinian Territories as well as its borders, especially with Lebanon.[40] Drones are particularly suited to this type of task, as they are far cheaper to operate than manned aircraft.[41] Persistent surveillance is also a tedious task that places high levels of stress on aircrews, so part of that stress can be relieved through the use of unmanned systems.

The advantages of unmanned systems in surveillance are particularly apparent along Israel's border with Lebanon. Hizballah has a fairly sophisticated network of air defence systems. If these systems were to shoot down a manned Israeli aircraft, it would lead to a significant escalation of the tension between Israel and Hizballah, with Israel likely launching a large–scale operation to recover the downed aircrew. In this context, UAS are considered expendable. Short of losing aircraft, violating Lebanese airspace with manned systems is considered more provocative by Hizballah than is the use of drones.

Israel has also used drones extensively for strikes.[42] Drones offer significant advantages over other weapons in the specific context of the Middle Eastern battlefield. Many strikes take place in dense urban environments with high potential for collateral damage. This places a premium on the capability to move close to the target and deliver a precise strike with a relatively small munition, something drones are particularly suited for.[43]

Turkey: From Importer to Export Powerhouse

As late as the first decade of the 21st century, Turkey used to purchase sophisticated UAS from Israel. Since then, a desire by the Turkish government to decrease dependency on foreign arms suppliers spurred government investment in the development of domestic replacements.[44] Turkish drones have been used extensively in counter–insurgency operations in southern Turkey, northern Syria, and northeastern Iraq,[45] though they have not reached the same level of seamless integration with other components of the armed forces as seen in Israel.

Iran: Sanctions-Shaped Industry, Mass, and Limits

Iran also has a fairly developed drone industry, the growth of which was spurred by the international sanctions regime that forces Iran to produce many of its weapons systems domestically.[46] Iranian drones are arguably less sophisticated than their Israeli or Turkish counterparts, due to the fact that Iran must independently produce all components, including sophisticated optical and electronic equipment. This puts Iranian drone producers at a disadvantage.

In confrontations against state actors, the performance of Iranian drones has been underwhelming. Russia has made extensive use of Shahed drones in attacks on Ukraine. The drones, at least in their most common configuration, have proven easy to shoot down and the damage they can inflict on high–value targets has been limited. Their main advantage is in their low cost, which enables high production volumes to overwhelm Ukrainian air defences and terrorize the civilian population.

Iran also used drones in large–scale attacks on Israel in April 2024 and June 2025, although, primarily as a decoy to occupy Israeli defences. Drones caused zero deaths on Israeli territory, while ballistic missiles, launched simultaneously, did inflict casualties.[47]

Aligned Proxies: Proliferation of Capability

Iran's allies, however, have been able to make more effective use of drone technology. Houthis who control a large segment of Yemen territory have received significant transfers of Iranian drone technology and know–how. The Houthis have used drones against their domestic enemies, as well as targets in Saudi Arabia, the UAE, and against ships in the Red Sea and the Gulf of Aden.[48]

Houthi drone operations against Saudi Arabia and ships in the Red Sea have pitted UAV against some of the most sophisticated air defence systems in the world with equivocal results. Saudi Arabia fields a multi–tiered system of air defences, including cutting–edge systems like the US–made Patriot in its latest configurations.[49] These modern air–defence systems have not been able to decisively protect Saudi territory from Houthi drone attacks. According to the Saudi military, the Houthis fired 851 drones against Saudi territory between 2015 and 2021, resulting in 59 civilian casualties.[50] Drones played a part in the Houthis' overall strategy, frustrating Saudi and UAE efforts, and indicating that UAS have the potential to contribute to successful strategic outcomes on the battlefield.

Similarly, in the Red Sea, shipping is protected by a defensive umbrella provided by warships with advanced air–defence systems. Partly due to the vast areas that need to be covered, these advanced systems have been unable to fully protect commercial shipping and Houthi drones regularly strike ships (although the Houthis also use missiles to target ships and it is missiles, not drones, that have been responsible for the majority of the successful strikes on shipping).[51] It should be noted, however, that there have been few, if any, incidents in which Houthi drones have successfully struck the warships themselves.

Hezbollah vs. Israel: Large Arsenal Meets Layered Defences

In Lebanon, Hezbollah has also developed a highly sophisticated drone arsenal, in large part thanks to transfers of Iranian technology and know–how. The case of Hezbollah's drone arsenal has broad implications for the future of drone warfare in general. Prior to the start of the ongoing war between Israel and Hamas, there was a consensus among analysts that Hezbollah's drone and missile arsenal would cause significant, if not catastrophic, damage to Israel should there ever be an escalation of hostilities. Hezbollah had built up an arsenal of at least 2,000 drones and as many as several hundred thousand other projectiles (mostly rockets, artillery shells, and missiles) it could launch at Israel.[52] It was considered likely that Israel would struggle to stop the sheer number of drones and missiles Hezbollah would use. Following 7 October 2023, such an escalation did take place with Hezbollah entering the conflict to support its ally Hamas, but the damage Hezbollah was able to inflict, though not insignificant, fell well short of devastating for Israel.

This is due to a combination of two factors. First, Israel has a number of **highly sophisticated air defence systems**, some of which are specifically designed to counter small, slow threats like drones. Secondly, these air defence systems are integrated into a **multi–tiered air–defence complex** specifically designed to counter the drone and missile threat.[53] This integration includes not only interceptor missiles that can destroy drones in flight, but also sensors that can pass information about drone and missile launch sites to air and ground units that can then swiftly target them through kinetic strikes. This type of rapid counter strike ensures the destruction of launch facilities and the elimination of missile crews and drone operators, which are more valuable than the drones and missiles themselves.

Integration, Counter-Strike, and the 'Post-Drone' Possibility

Israel's level of integration of its counter–drone capabilities into a broader battlefield management system is unprecedented and has not been reproduced with the same scale and effectiveness anywhere else. Furthermore, they can do so largely with technology that is already available, and battle tested. Perhaps if the adversary had been more sophisticated, more drones would have penetrated Israeli airspace. The opposite is, however, also possible, if neither side would have been able to effectively use drones. It may have simply become too dangerous to launch drones and if both sides had effective anti–drone systems, the majority of drones that were launched by either side would have been brought down by countermeasures. This indicates the **post–drone battlefield is not far–fetched**.

DIY & COTS on the Syrian Battlefield

Most militaries and armed groups are still far from reaching the level of sophistication needed to impose a post–drone battlefield. In fact, the most common use of drones in warfare is likely to involve cheap, simple systems – either **commercial–off–the–shelf or assembled using rudimentary techniques – to carry out simple tasks against unprepared adversaries**, democratizing drone warfare and making it available to a broad array of actors. The case of drone use in the Syrian civil war is illustrative of this trend. The most common use of UAS in Syria involved commercial quadcopter drones either for surveillance or simple strike tasks, as seen, for example, in an attack on the graduation ceremony at a military academy in Homs in 2023 that killed as many as 100 people.[54] Basic commercial quadcopter drones, such as those produced by Chinese DJI, require almost no modification for this purpose and crews require almost no training. The cost per unit of such drones, which are re–usable, is less than $5000. When rebel groups used drones against the Assad regime, they were usually **confronting an enemy that had no effective counter–measures available**. Syrian rebel groups were largely able to figure out how to use drones for this type of operation without any outside assistance, though there is credible evidence that Ukrainian special forces did provide rebels some support in the late stages of the war. That support allowed the rebels to strike some high–profile Russian and regime targets. Even these more sophisticated attacks, including a strike on an airfield hosting Russian combat aircraft and protected by Russian EW systems, were largely carried out using the most basic UAS.[55]

Two Futures—Cheap Disruption vs. Contested Skies

In the Middle East, drones are re–shaping battlefield dynamics, sometimes in unexpected ways. They have given useful **new offensive and reconnaissance capabilities** to both states and non–state actors, but Israel's experience in its conflict with Hezbollah since October 2023 shows that **integrated defences can significantly blunt their effect**. The experience from the Middle East shows that the impact of drones on the future of warfare will be characterized by this **dual dynamic**: advanced militaries may come close to imposing a post–drone battlefield scenario, while cheaper systems will give less sophisticated actors disruptive power when confronting unprepared adversaries.

Chapter III –
PATHWAY TO THE FUTURE

The key assumptions and critical uncertainties analysed in the first two chapters represent today's perception of the security environment and the changes that the integration of drones may bring to it. They reflect the current – second drone era. From here, a path leads into the future – the third drone era – one that will be paved by the **driving forces of change**: strategic trends that will shape the security environment of the Alliance. This report identifies five such change drivers which, individually or through their mutual interaction, will determine the shape of the next drone era:

UNMANNED ASYMMETRY AMPLIFICATION will be driven by deniability of drone operations, their asymmetric advantages, and their operational flexibility. These factors, further strengthened by scale, speed, range, cost, accessibility, and ease of use, will lead to a democratisation of warfare, providing both smaller state and non–state actors with capabilities that were previously out of their reach.

These trends may be further accelerated by the continued **EVOLUTION OF DRONE TECHNOLOGIES**, particularly if advanced systems continue to proliferate. In addition to security challenges, this development is likely to raise significant ethical and legal issues related to AI adoption and human–machine teaming.

A natural response will be the development of counter–drone technologies, fuelling a **COUNTER–DRONE ARMS RACE** and questioning the future of deterrence, especially as the hider–finder dynamic triggers a drone–versus–counter–drone innovation spiral.

Growing **GEOPOLITICAL COMPETITION** will introduce additional considerations into the strategic equation. Supply chains, critical components, and critical raw materials – their availability and weaponisation – will play a key role in scaling the drone operations. Building global partnerships and establishing rules for the legitimate and proportional use of drones will become an integral part of the next drone age.

UNIVERSAL PROLIFERATION can ultimately become both a consequence and a driver of these trends. It will have both quantitative and qualitative dimensions and can significantly influence the strategic calculus of both state and non–state actors, particularly if this proliferation extends to the area of advanced software–defined capabilities, including semi–autonomous and autonomous platforms.

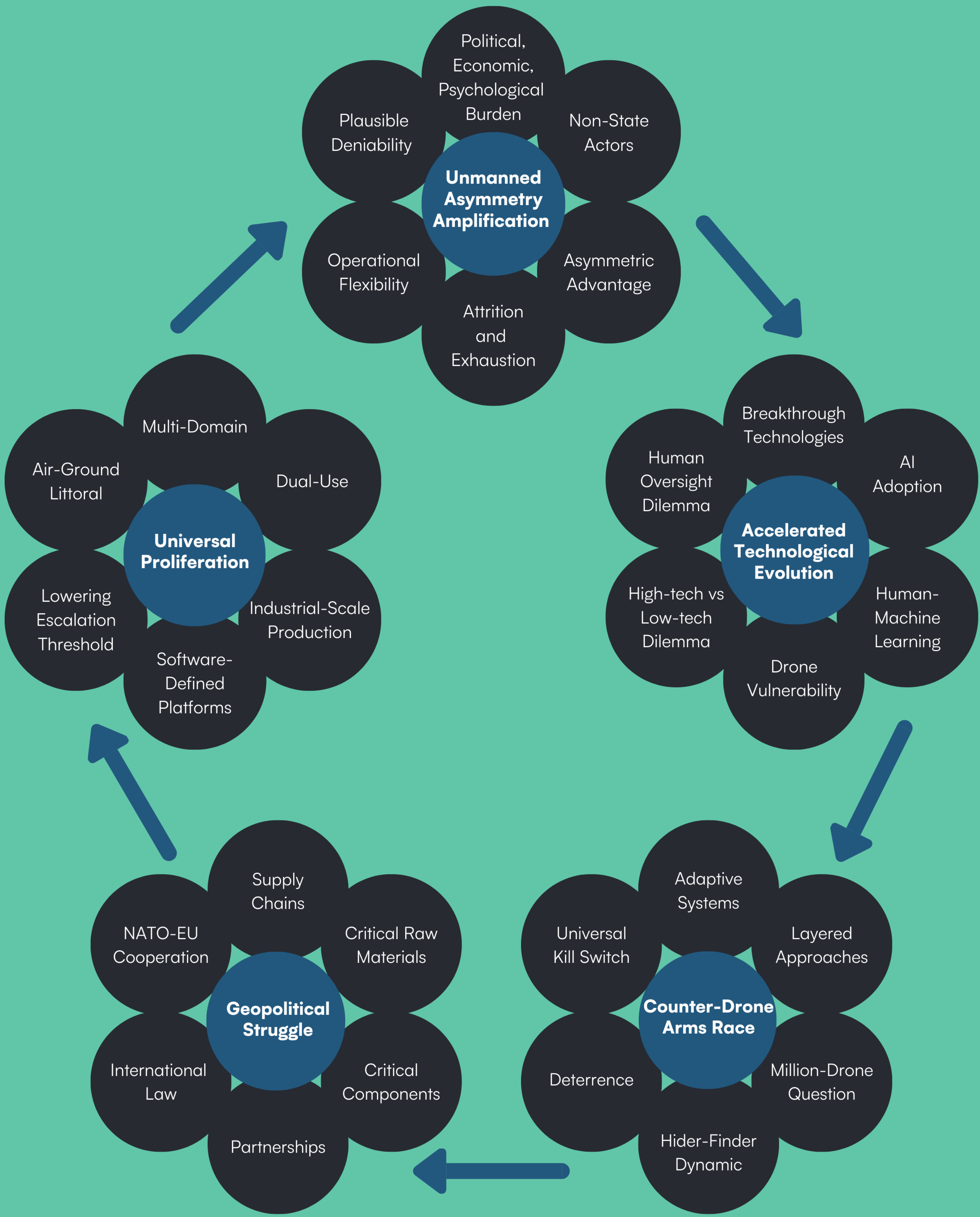


Figure 2: *Change drivers*

UNMANNED ASYMMETRY AMPLIFICATION

Actors such as ISIS, the Houthis, and drug cartels – alongside states – have leveraged UAS for ISR (intelligence, surveillance, and reconnaissance), logistics, smuggling, precision strike, and psychological operations. This demonstrates how UAS have been successfully **integrated across the competition continuum**, from low–intensity conflicts to high–intensity interstate wars.

Plausible deniability, asymmetric advantage, and operational flexibility are three attributes that make drones particularly well–suited for below–threshold operations.[56] The fusion of civilian innovation and military utility lies at the heart of their dual–use nature. Drones can deliver **cross–domain** (air, land, maritime, space, and cyberspace) and **cross–dimension** (physical, virtual, and cognitive) effects.

In December 2018, Gatwick Airport was brought to a standstill by reports of unauthorised drones – sometimes two seen at once – forcing an emergency shutdown. There were 170 reported sightings, 115 deemed credible, though no hard evidence emerged. The shutdown lasted roughly 36 hours, with intermittent closures extending disruption to about 45 hours. The incident caused around 1,000 flight cancellations, stranded 110,000 passengers, and inflicted significant financial damage. No culprit was ever found.[57] Similar incidents over Brussels, Berlin, Munich, Copenhagen and other European airports in 2025 indicate this kind of threat is on the rise.

Germany has witnessed multiple drone sightings near military and industrial sites, including U.S. Ramstein Air Base, arms manufacturer Rheinmetall, and chemicals group BASF. Authorities raised espionage concerns amid heightened tensions related to the war in Ukraine.[58] Similar reports of unidentified drones over military installations, arms factories, nuclear plants, and critical infrastructure have emerged across several states in the US.[59] Other examples of drone–enabled coercion, including kinetic strikes, are the Houthis' aerial campaign against Saudi Arabia since 2015[60], as well as their ongoing effort to disrupt maritime trade in the Red Sea.[61]

To grasp what's coming next, we need to imagine how the threat picture will change once **battle–tested tactical know–how and technological innovations** born (not only) in the Russo–Ukrainian war will reach various **non–state actors**. Such capability diffusion is arguably inevitable, and will become a powerful source for even further democratisation of warfare. UAV equipped terrorist organisations might become much more dangerous, lethal and disruptive. **Private military and security companies** (PMSCs) might become spearheads of geopolitical competition and proxy warfare, and drone–enabled capabilities could aggravate the challenges they pose to international security[62] or even to liberal international order.[63]

Scale, **speed**, **range**, **decreasing costs**, and **increasing ease of use** will be the most impactful **asymmetry increasing factors** shaping the drone threat from violent extremist organisations.[64] The improvised explosive device (IED) nightmare is back, airborne, high speed and increasingly autonomous.[65]

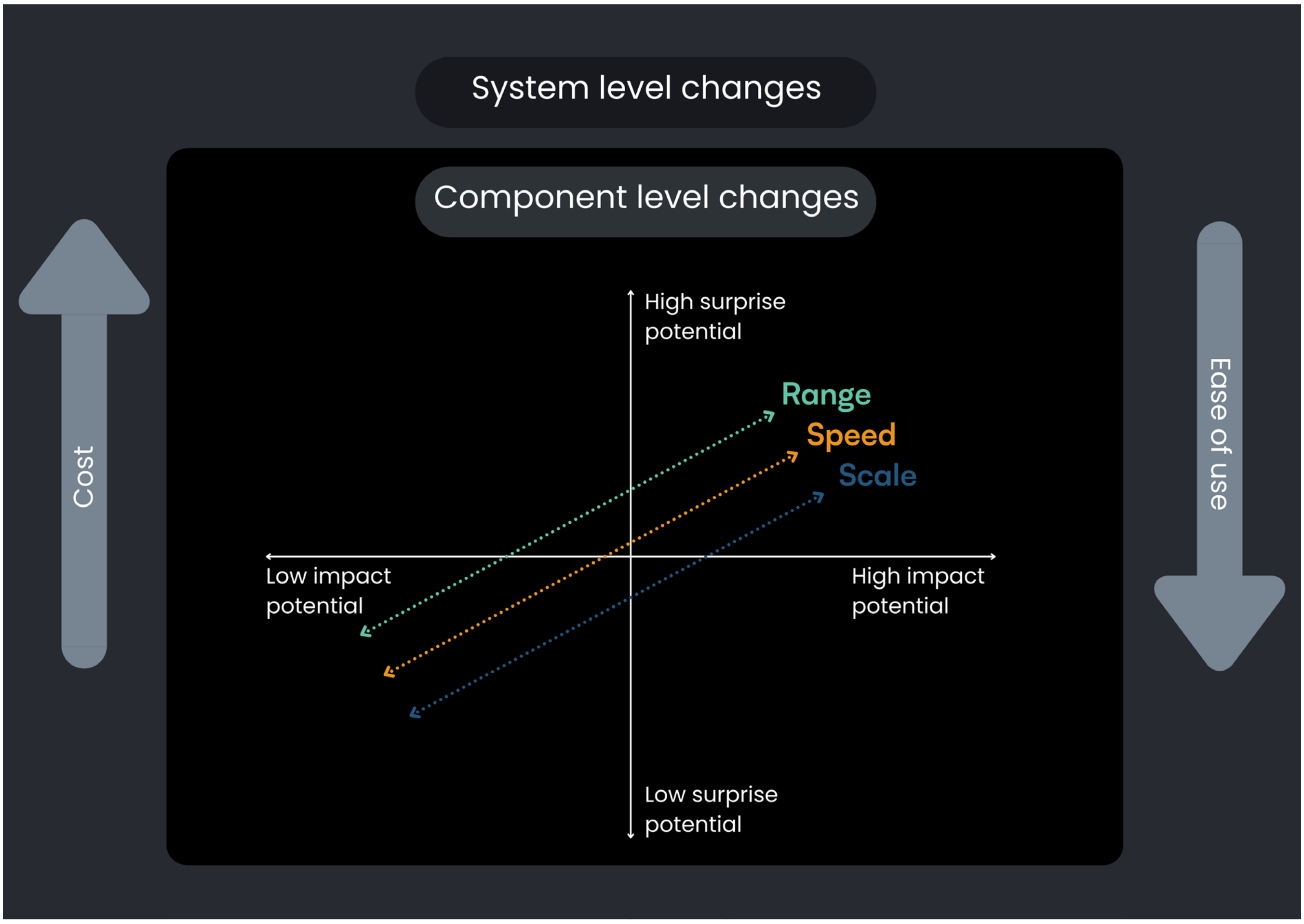


Figure 3: *VEO Drone Capability Impact Framework.* *Don Rassler and Yannick Veilleux-Lepage, CTC Sentinel*

Law–enforcement agencies are already routinely confronted with drone–enabled smuggling, surveillance, and disruption at prisons, border checkpoints, and major public events. Clear legal frameworks and technical counter–UAV capabilities are lagging. Upgrading both to the level of relevance across the **national security apparatus** will be a complex challenge combining administrative, regulatory, organisational, economic, and technological aspects.

Also, **countermeasures** – such as jamming, spoofing, hacking, and directed energy, to name a few – **are** already being **weaponised** and will increasingly be weaponised for below–threshold disruptive operations by adversaries and malign actors. Available, multipurpose, low cost, portable, and concealable spoofing devices are already a reality.[66] Real–world disruptions from Global Navigational Satellite System (GNSS) spoofing in the Baltics[67] and the Strait of Hormuz underscore this double–edged dynamic.[68] With UAVs embedded into critical infrastructure and the operations of various security agencies, disrupting them may potentially cause **significant capability degradation** during a time of crisis.

From nuisance overflights, close passes, to propaganda–boosting drone footage and espionage, there is "micro–damage" designed to coerce without inviting overt retaliation. The desired strategic effect for the perpetrator is attrition and exhaustion.

From the defender's perspective persistent omnipresence of drone threat will present a **significant political**, **economic** and **psychological burden** for targeted countries. For those already weak and fragile, this can be just enough to push them into a spiral of instability and violence. For those reasonably well–resourced and robust foreseeable negative effects span from over–securitisation and fragmentation of threat perception to partial decision–making paralysis – all collectively contributing to a decreasing trust and legitimacy of the state in the eyes of its own citizens.

ACCELERATED TECHNOLOGICAL EVOLUTION

Advancements in unmanned technologies alter defence capabilities and threat landscapes. There is a multitude of technological advancements that can improve drone efficiency, performance and resilience and lead to "incremental development having disruptive payoffs".[69]

Advanced **propulsion** systems (hybrid, hydrogen fuel cells, photovoltaic systems, supercapacitors)[70] can improve UAV efficiency and endurance, and when combined with advanced designs and materials, it can contribute towards silent drone operations,[71] improving stealth by minimizing acoustic signatures. **Stealth** technologies, in general, are likely to emerge as a new area of technological competition.[72] A field with broad application is **miniaturisation**[73] and **nanotechnology**[74], allowing for the creation of smaller, lighter, smarter, and more efficient materials and drone components. Miniature drones themselves[75] can be produced and deployed at large scale, evade detection and significantly increase surveillance and espionage concerns. **Sensorics** (multi–sensor fusion, multi– and hyper–spectral imaging, compact–radars) and resilient **communication**[76] are among key enablers of drone capabilities which can be further enhanced by utilizing blockchain concepts.[77] Advancements in **long–range** and **hypersonic** UAVs could redefine strategic depth and erode the safe rear. The next generation of drone disruption is linked to the adoption of **quantum technologies** in navigation[78], communication, and sensorics, with potentially significant improvements in resilience, autonomy, and precision.

While the multitude of possible technological advancements will provide ample alternatives for reshaping **tactical and strategic calculations, three areas stand out:**

- **AI adoption:** as a general–purpose technology, AI is poised to transform a broad range of military drone functions – from ISR, logistics, and maintenance, to enhanced navigation, real–time detection, tracking, and decision–making, and autonomous swarm coordination. AI has the potential to shift drones from a merely **quantitative to a qualitative force multiplier**.[79] Yet, the pace of progress in AI–enabled systems has already outstripped the evolution of political, ethical, and legal frameworks governing their use. The deployment of autonomous and semi–autonomous weapons is already taking place.[80] The coming decade will therefore hinge not only on technical innovation, but also on the establishment of robust governance mechanisms to reconcile military advantage with ethical and legal responsibility.
- **Addressing drone vulnerability**: although drones are often portrayed as game–changers or even "silver bullets" of future warfare, they possess inherent vulnerabilities. Their effectiveness will depend on the ability to operate in contested environments, where electronic warfare (EW), and cyber interference will be prevalent. Moreover, the accelerating development of counter–UAV "hard kill" technologies will increasingly challenge drone operations. Ensuring operational resilience will require advances in protection, redundant communications, and adaptive tactics. Beyond technical hardening, drone survivability will ultimately rest on a **systems–level approach** – creating a layered force structure combining expendable mass with a core of highly capable systems and a resilient, broader ecosystem including robust supply chains, rapid field repairs, and modular replacements.
- **Human–machine teaming:** the compression of decision–making cycles and the use of swarming involving simultaneous control of dozens or even hundreds of drones per operator will push human cognitive and physical limits. Managing complex, high–speed operations will increasingly depend on advanced human–machine interfaces, where technologies such as virtual and augmented reality (VR/AR), or neurotechnology[81] seek to enhance situational awareness, coordination, and control. However, as human and machine roles become more integrated, it will raise profound questions. **Balancing efficiency** and operational speed **with the preservation of human judgment and moral responsibility** will be one of the most delicate challenges in the future of drone operations.

If the present drone age is defined by proliferation and scaling of mostly cheap, yet still disruptive drone technologies, the **next drone age** is likely to be defined by the diffusion of drone sophistication led by AI adoption. This raises **two strategic dilemmas:**

- **Mass vs. sophistication – the high–tech vs. low–tech dilemma:** emerging UAS capabilities promise to enhance drone resilience, endurance, and operational versatility. Yet, these advancements will inevitably raise unit costs and depend on access to complex supply and value chains, which may constrain scalability and resilience of production. The evolution of military drone systems will thus increasingly hinge on the **trade–off** between **technological sophistication** and **force mass**. The central question is not necessarily going to be "either mass or sophistication," but how to integrate multiple tiers of technological complexity into a coherent force structure. Future drone fleets are likely to blend high-end platforms with low-cost, attritable systems. This layered approach will demand new doctrines for interoperability, data fusion, and decision-making, ensuring that heterogeneous drone swarms function as unified, adaptive systems. The defining challenge of the next decade, increasingly shaped by software-defined weapons, will be achieving **"intelligent mass"** – leveraging advanced technologies selectively to enable scale, rather than replacing it with sophistication alone.

- **Autonomy vs. control – the human oversight dilemma:** the integration of autonomous systems into military drones will significantly enhance their capabilities. However, increasing autonomy raises fundamental questions about command authority, decision-making, and the ethics of machine-initiated action. As AI assumes a larger role in target selection, mission adaptation, and engagement decisions, it challenges traditional notions of command responsibility, rules of engagement, and legal accountability. These dilemmas extend beyond domestic governance. In conflicts involving adversaries who operate under different ethical frameworks or disregard international law altogether, the asymmetry in rules of engagement may incentivise greater automation simply to remain competitive. These dynamic risks create a **technological and moral escalation spiral**, in which speed and algorithmic advantage override human judgment and restraint. Navigating between HITL, HOTL, and HOOTL designs will require the development of robust human-machine command architectures, transparent AI governance frameworks, and internationally recognised norms of accountability.

COUNTER–DRONE ARMS RACE

The rapid spread of drones is driving growth in **counter–drone technology** aimed at restoring balance in military and civilian airspace.[82] Since UAVs provide a strong offensive edge through low–cost, mass deployment and flexibility, the strategic challenge for defence and national security is to **adopt adaptive systems** and deliver **cost–effective solutions**.

As no single system can counter all drone threats (from Class I to Class III), defence requires **layered approaches** that start from first responding and detection forces, to neutralisation by either soft kill (e.g., jamming, spoofing), hard kill techniques (e.g., nets, projectiles) or other methods (e.g., trojans, de–authentication).[83] Effectiveness depends on coordination and rapid data sharing[84], especially for adaptation to swarm tactics.[85] Maintaining effectiveness will also require a **faster innovation cycle**, as traditional EW methods may become partially or entirely obsolete in the face of AI– and quantum–enhanced navigation, sensing, and encryption.

Effective strategies for a comprehensive counter drone system will combine soft– and hard–kill measures with robust cyber defence, creating a non–linear interplay between **offense**, **defence**, and **counter–defence** that will define the future of drone warfare. The competition between offensive and defensive drone technologies has become central to a **hider–finder dynamic**, where each counter–drone advancement spurs new offensive innovations, and vice versa.[86] This ongoing cat–and–mouse game ensures that counter–drone systems deliver only temporary solutions before adaptation diminishes their effectiveness. This interplay is further complicated by inherent **drone vulnerabilities** impacting both the offence–defence balance and cost–exchange ratio. Addressing drone vulnerabilities is therefore one of the central challenges of the next generation of drone–versus–counter–drone dynamics.[87]

Counter–drone application is also expanding into **civilian life** where public spaces and events rely on them, creating blurred boundaries between defence and public safety. Drone proliferation challenges both **external and internal dimensions of security**, reshaping how defence responsibilities are shared, regulated and distributed domestically among different actors – both public and private. This will shape how counter–drone measures are approved and used, as authorities seek to balance public safety with individual rights.[88] Awareness raising, training and coordination will be essential, as drone risks are shifting from a purely military task to a **responsibility shared across the whole national security system**. A similar reconsideration of tasks and responsibilities should take place also between **NATO** and the EU.

Cost–exchange ratio has always been the decisive element for air–defence, but UAVs have brought new dynamics into this domain, as CUAS systems represent the much–pricier side of the equation. As no counter–drone system may remain fully effective, especially against large–scale swarms or combined drone – missile attacks, the prospect of mass drone warfare — the **"million–drone question"** *(What would a potential drone attack on a massive – "million" – scale mean?)* — forces difficult choices about how states can protect themselves and what to protect first. Prioritising protection raises **cost and coverage dilemmas**: whether to divide, and how to balance protection among military, governmental, critical infrastructure, and civilian targets.[89]

In this context, **procurement** becomes a critical factor.[90] The strategic question becomes not only how quickly to procure, but **what to procure** in a rapidly developing security environment, especially for countries in peacetime. High development and maintenance costs may become prohibitive, especially for smaller states, highlighting the need for cooperative procurement, shared research, and scalable solutions that make innovation accessible beyond major powers.[91] This dynamic has contributed to the rise of a fast–growing global industry in which governments and corporations compete to dominate the market.

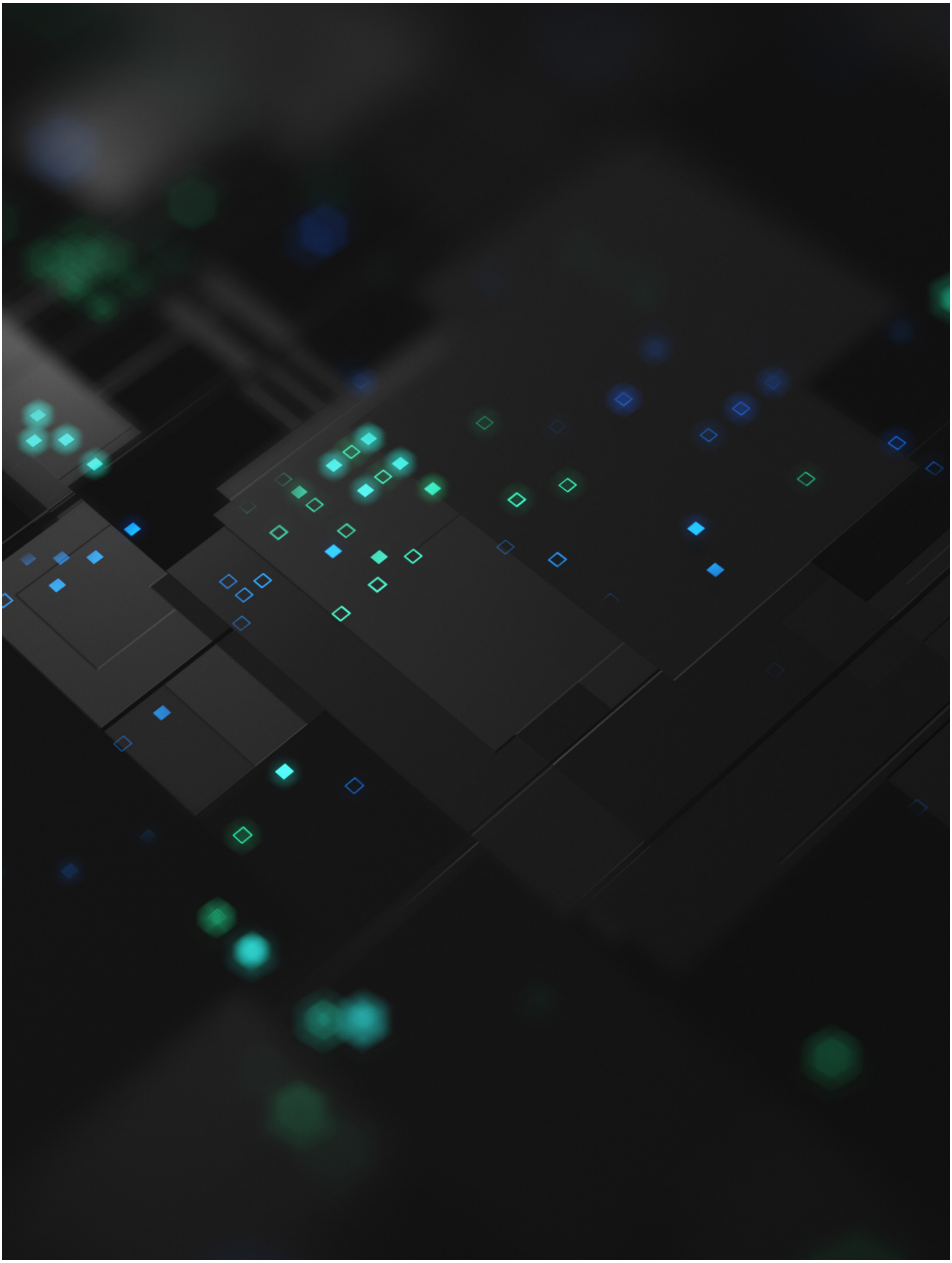
Counter–drone wild card – the universal kill switch

A universal kill switch capable of instantly neutralising drones would deliver decisive strategic advantage and overturn existing drone doctrines. It may come from the technological breakthrough capable of "killing" every drone in the sky or by more effective technology capable of replacing drones.

Given the rapid cycle of innovation and response, **diversifying counter–drone measures** is essential.[92] Ultimately, the most effective counter–drone strategy may be credible capability and willingness to destroy drones before they are even launched. This leads directly to the core issue of **deterrence**.[93] Drones inherently lower the risk threshold and thus erode deterrence, as absence of human presence and the deniability of drone operations make them attractive tools for testing an adversary's response. A demonstrated capability and clear willingness to employ offensive drone waves might contribute to deterrence by punishment but also raise questions of proportionality and escalation management. On the other hand, deterrence by denial could provide some solutions, if employing intelligent mass and ubiquitous CUAS presence is manageable with reasonable cost–exchange ratios.

The **strategic consequences** of the counter drone arms race lie in rising defence costs, procurement pressures, and the need for layered counter–drone systems. Civilian and military security are becoming ever more intertwined as counter–drone tools enter public spaces, creating significant regulatory and privacy dilemmas.

Drone penetrations of sovereign allied airspace test NATO's deterrence posture, raising questions about political coherence and the Alliance's ability to field cost–effective military capabilities that enable NATO not only to condemn drone provocations, but also to really deter such actions through credible strike capabilities.[94]



GEOPOLITICAL STRUGGLE

Growing geopolitical rivalry and strategic competition are driving the securitisation of drone–related supply chains.[95] This is contributing to geopolitical fragmentation, where trade wars, export barriers, and sanctions expose strategic vulnerabilities. The concentration of production and processing outside the transatlantic region further amplifies these risks.[96]

Control over essential components and critical raw materials CRM has become strategic leverage, turning access to these elements into a vital component of drone supply chains.[97] In response, states and alliances are prioritizing resilience by forming new **partnerships**, building trusted supply corridors, and pushing toward strategic autonomy to shorten the lead time by nearshore, friendshore, onshore production, co–production, stockpiling, and recycling efforts. Alongside these costly, time–consuming new industrial policies, it is also necessary to maintain a strategic edge in advanced technologies such as software, semiconductor components, and chips.[98] For ensuring strategic advantage in the context of one of NATO´s three core tasks[99] – **cooperative security** – it is essential to deepen ties with like–minded partners focused on supply chain security, capability development, and defence production.[100]

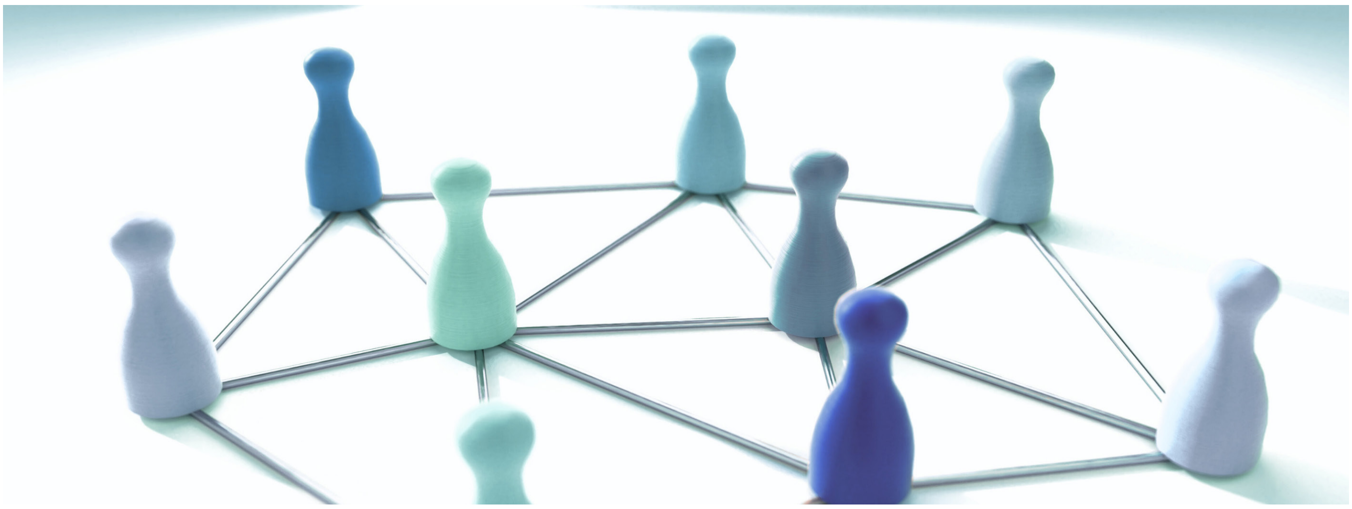
NATO–EU cohesion will be equally important. This involves not only sustaining mutual awareness, identifying synergies, and sharing best practices on emerging and disruptive technologies (EDTs), but also moving beyond coordination by aligning priorities on dual–use applications of AI, quantum, and biotech, with a strong focus on financing, investment, and innovation standards, followed by the real implementation of actionable research products.[101]

Among partners, **Ukraine** stands out as a "change driver in itself" in the military drone sector, shaping modern warfare by not only becoming a powerhouse of drone manufacturing, but also by testing new technologies and tactics in real combat. The challenge for Ukraine and its partners will be sustaining this momentum in the post–conflict period to continue advancing leadership in drone technology.

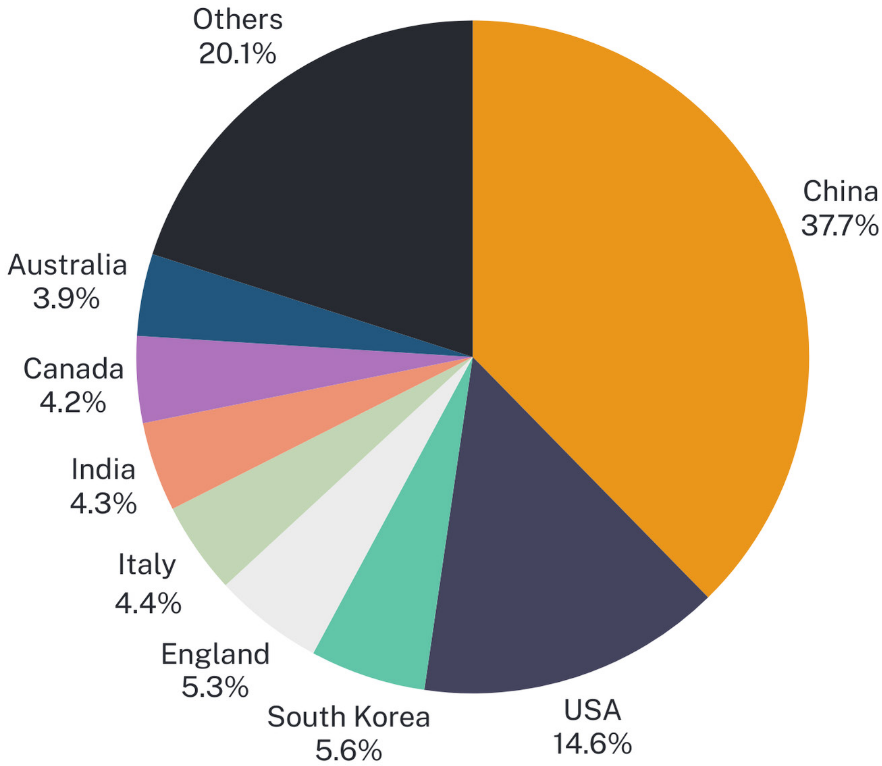
While the global geopolitical landscape remains focused on great powers, the rising influence of middle and small powers demonstrates how rapidly the competitive landscape is shifting.[102] States are increasingly using hi–tech UAV and counter–UAV systems as tools of **influence and drone diplomacy**.[103]

For another NATO core task – **crisis prevention and management** – the growing exploitation of drones and the widening gap between technological realities and legal regulation pose a significant challenge, underscoring the **urgent need for new global governance mechanisms and ethical oversight** to ensure stability and responsible use.[104] Drone development and proliferation have the potential to reshape the legal and security environment by eroding compliance with established international law and deepening legal grey zones.

When "unmanned means unaffiliated," it **lowers the conflict threshold** and **blurs casus belli**. Drone export control is difficult, as the MTCR (Missile Technology Control Regime)[105] covers only large systems, while distributed local production hinders monitoring and restriction efforts.[106] This may spark a contest over norms defining legitimate use, targets, and proportionality, as competing national narratives risk undermining humanitarian law and obstructing arms control.[107] Given this uncontrolled proliferation trend, and its potential to further deteriorate the security environment, NATO should step up efforts in developing international control frameworks and regulatory mechanisms for the global norm–building process.



The **strategic consequences** of the geopolitical struggle lie in the weaponisation of critical raw materials and essential components, creating volatile drone supply chains and driving reshoring to maintain a technological edge. Power is increasingly redistributing as middle and lower powers expand drone capabilities, with Russia–Ukraine war accelerating innovation. Within the framework of cooperative security, established NATO partnerships and like–minded countries play a key role in building supply–chain resilience. In line with NATO's crisis–prevention and management core task, the legal uncertainty surrounding autonomous systems heightens escalation risks, creating a need for new international rules and regulatory mechanisms to address the evolving landscape of drone warfare.



Graph 4: *Results from Web of Science Core Collection for Articles (in %)*

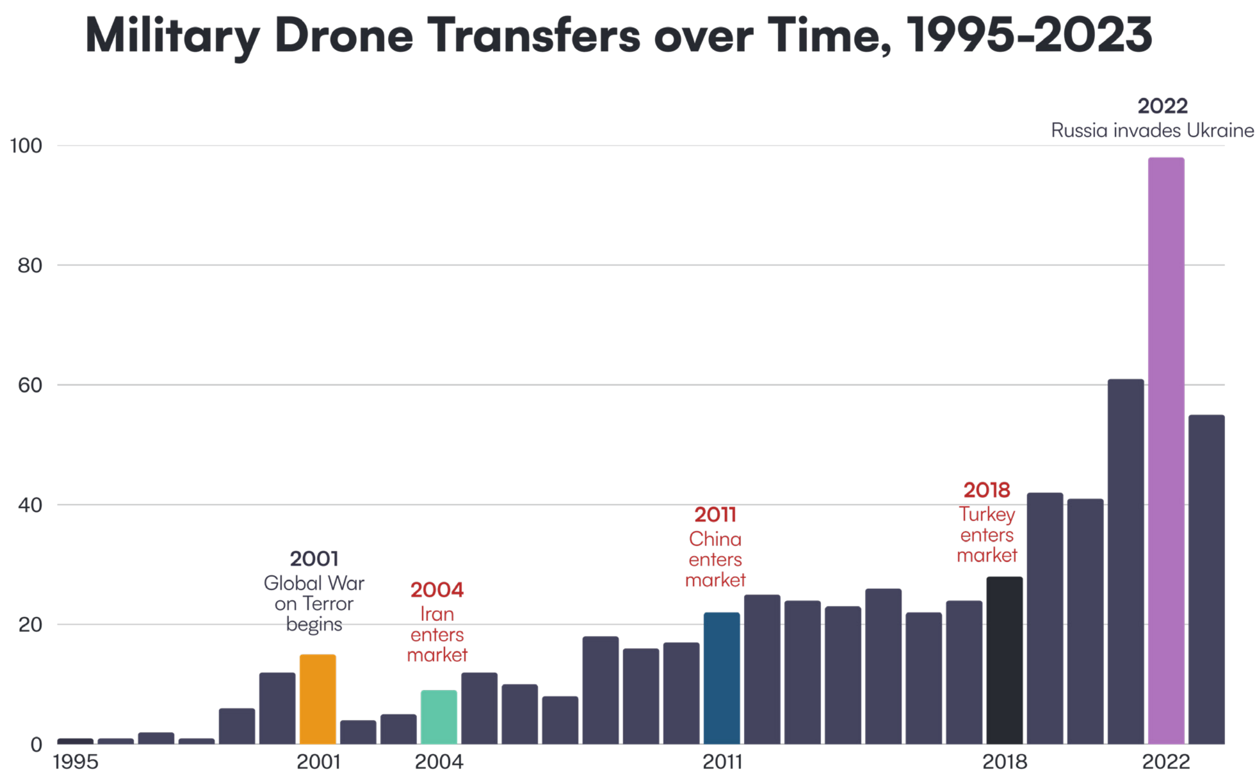
According to the Web of Science Core Collection, the keywords "drone" and "UAV" appear in 65,263 scientific articles published up to November 2025. The results indicate that more than half of this research activity originates from China and the United States.

UNIVERSAL PROLIFERATION

Universal proliferation refers to the rapid, multi–dimensional spread of unmanned platforms – both in quantity and in quality. It covers not just new types or categories of drones but also their expanding applications and increasing technological sophistication. While unmanned aerial systems (UAS) dominate today, ground, water surface, and underwater platforms across different size and purpose categories are emerging quickly. Drone proliferation is global, diffuse and decentralised, spanning military, civilian, and commercial sectors.

A 2024 Danish Institute of International Affairs report identified over 65 non–state actors using drones for surveillance and strikes.[108] The main acquisition pathways, as outlined by the United Nations Office of Counter–Terrorism report on the use of UAS by non–state armed groups for terrorism–related purposes are **commercial procurement**, **illicit trafficking**, **illicit manufacture** and **modification**. Falling costs, broad commercial availability, and high operational utility are driving the proliferation logic.[109]

In 2010 only three states owned armed drones; by 2022 the number had risen to thirty–nine.[110] Major and middle powers now develop and export indigenous platforms (China, Turkey, US, Israel etc.) or **adopt and upgrade foreign designs** and push them for **mass production** (e.g., Russian adoption of the Iranian Shahed drones).[111] Proliferation ranges from **Class 1** to **Class 3** assets and includes **multipurpose** as well as one–way **suicide platforms**.



Graph 5: *Military Drone Transfers over Time, 1995-2023, Data Source: Molly Campbell/Center for a New American Security*

CNAS Drone Proliferation Dataset offers insight into global transfers of military–grade aerial drones – armed and unarmed – **from 1995 to September 1, 2023**. CNAS data highlights two key trends: a sharp **rise in total transfers** and a **shift from dominance of large armed platforms toward smaller** tactical drones and loitering munitions.[112]

The Russia–Ukraine war has **accelerated global investment and adoption** of drone technology. The military drone market size was valued at USD 14.14 billion in 2023 and is projected to grow from USD 16.07 billion in 2024 to USD 47.16 billion by 2032, exhibiting a CAGR of 13.15% during the forecast period.[113]

Industrial–scale production is pushing costs down while improving performance, enabling even low–budget actors to acquire sophisticated systems, or tens of thousands of simpler tactical platforms.[114]

Commercial drones add another layer. Equipped for beyond visual line of sight, vertical take–off and landing, increasing autonomy and payload capabilities, drones bring advances to sectors such as agriculture, construction, logistics, and urban mobility, forming the foundations **of a low–altitude economy**.[115] Between January and March 2025, the U.S. Federal Aviation Administration reported over 411 illegal drone incursions near airports across the United States – a 25.6% increase from the 327 reports during the same period in 2024.[116] **Managing increasingly crowded airspace** will therefore inherently become a multi–stakeholder endeavour with far–reaching implications for national security apparatus, including for armed forces.

In parallel, a comparable shift is unfolding in the military sphere. The rise of **Air–Ground Littoral** concept – driven by the democratisation of airpower through inexpensive UAS – reflects deeper **domain convergence** and its operational impact on **combined arms warfare**.[117]

Universal proliferation is driven by overall **hype**, **strategic rivalry**, **dual–use nature of unmanned technology**, **commercial incentives**, and **ease of use**, making continued spread all but inevitable.

A key strategic effect already visible is the **lowering of escalation thresholds** across multiple regions. UAVs diffusion projects conflict potential into strategic choke points (e.g. Bab–el–Mandeb) or areas that were once strategically remote, including maritime and polar regions.[118] States are deliberately transferring drone technologies to state and non–state partners as part of a proxy warfare strategy.

Looking ahead, beyond cheap and rudimentary systems, **advanced software–defined capabilities—including semi–autonomous, and autonomous platforms**—are also likely to proliferate widely. Future planning should focus not only on the threat from the above – UAVs – but also from the unmanned ground vehicles (UGVs), unmanned underwater vehicles (UUVs) and unmanned surface vehicles (USVs). Each domain will require integrated, domain–specific countermeasures.

Multidomain unmanned operations are already emerging. This trend will not be limited to advanced militaries: violent non–state actors are likely to adopt similar practices. **Domain convergence** might present serious organisational and C2 challenges, as responsibilities overlaps are likely to deepen. At the same time, simultaneous push for increased multi domain **synchronicity**, **decentralisation** and **delegation of authority** down the command chains could create unexpected challenges ahead.

Chapter IV – THE NEXT DRONE AGE

As we do not have data from the future, strategic foresight does not aim to predict the future; rather, it aims to anticipate future developments and prepare for what has yet to happen. To manage uncertainty, this research developed **four scenarios** to explore alternative futures and encourage deep, creative thinking about the trajectory of unmanned systems and their impact on security, defence, and, more broadly, society and the economy.

> **"Facts, by definition, are 'of the past'. The future has not yet happened and cannot be empirically observed or measured. But it can be experienced through imaginative storytelling, immersive learning and using collaborative approaches to group model building and whole systems thinking."[119]**
>
> *Angela Wilkinson*

The goal is to explore plausible options and offer strategic thinking that can support Allies' strategy development and subsequent strategic planning.[120] The following scenarios are neither predictions nor strategies. They are not normative, as they do not propose a preferred or optimal future. Instead, they are exploratory scenarios[121] intended to describe plausible future developments from status–quo and incremental change to transformative and wild–card ones over a 15–year horizon. They can serve as benchmarks for future strategy development. The actual future will most likely emerge at the intersections of these scenarios. Therefore, prudent strategic planning should account for all options, whether through deliberate strategy or contingency planning.

Democratisation of Warfare

Balance of power is rewritten, and deterrence erodes as proliferation provides asymmetric advantage to smaller states and non-state actors. Hybridisation of warfare increases, and continuous low-intensity conflict becomes the norm. A lowering threshold for military engagement and the expansion of home-grown threats provide fertile ground for frequent, fragmented, and decentralised violence.

Software Defined Future

Robots, AI agents, big data, and advanced autonomy define the mode of warfare. Software-defined warfare surpasses the traditional horizons of military commanders. Code sophistication, computing power, engineering talent, and institutions fostering innovation become defining factors that differentiate winners from losers.

Ubiquitous Drone Presence

Drones become organic extensions of soldiers. Human—machine integration, drone integration and interoperability define strategic advantage. Human judgment remains central as drones create near-total battlefield transparency. Logistics shifts forward with frontline production. Power depends on the resilience of a nation's drone ecosystem. Warfare becomes drone-integrated, where cohesion and rapid agility win.

Post-Drone Age

Multilayered defences, saturation, and transparency neutralise low-altitude operations. Global restrictions limit autonomous weapons and swarms, enforcing human oversight. Drones persist mainly in support roles while innovation shifts to quantum sensing, cognitive EW, and AI integration. The battlefield moves to high altitude, space, and the digital cloud, leaving drones abundant but strategically secondary.

DEMOCRATISATION OF WARFARE

The low cost, scalability, and accessibility of drones **transform the character of conflict** and power dynamics.

Balance of power is rewritten on a regional or a global scale. Power is defined not primarily by the size of a state, but by technological prowess, scalable production, and the adaptability of armed forces. Technologically affluent and rich nations, or non-state actors, gain asymmetric advantage. **Deterrence erodes** as even small actors can intervene against powerful nations via deniable drone attacks.

As a result, **continuous low-intensity conflict becomes the new norm**. The number of chronic threats increases in the unstable NATO neighbourhood, beyond the Eastern flank, placing greater strain on security systems and budgets. The number of failing states is growing. Weak or poorly governed states face a risk of being left behind, lacking the technical, administrative, legal, human, and economic capacities to cope with an increasingly complex security environment.

Hybridisation of warfare increases as the line between peace and war blurs. Conflicts unfold in grey zones. Drone-based attacks, espionage, assassinations, and sabotage become frequent. Drones are increasingly used for psychological warfare or testing the adversaries' capabilities and determination.

Drones are mass-produced and widely available. Commercial drones can be easily modified – making off-the-shelf warfare commonplace. Military drones control regimes are either missing or ineffective, resulting in unchecked drone **proliferation**, both in quantity and quality.

Formerly state-exclusive capabilities become accessible to **non-state actors** – including illegal groups (e.g., terrorists, criminals), and private military contractors – expanding their force projection and further widening the grey zone in which they operate.

Home-grown threats intensify: insurgents, terrorists, lone-wolves, criminals or proxies can plan and perpetrate their malign activities without external supplies or support, heightening domestic threats and complicating state response and their effective control.

Proliferation and the growing importance of drones accelerate a global **Drone Arms Race**. Drone and counter-drone development form a continuous escalation spiral. **Counter-UAV democratisation** adds another layer of complexity and insecurity as adversaries or malign actors can attack the inherent vulnerability of drones not just in military, but also civilian domain.

More actors cause more instability and eventually even more conflicts. The **threshold for military engagement decreases** through financial considerations (drones are cheap) power calculus (size of country and manpower is less important), political cost (limiting soldier exposure, less casualties, attribution is murky) or autonomous escalation (diffusion of AI-enabled autonomous or semi-autonomous drones leads to algorithmic decisions, misidentification, or autonomous counter-response loops). As a result, the world witnesses **frequent**, **fragmented**, and **decentralised violence**.

"I really believe that this is the future of warfare, like gun-powder was in the Hundred Years War, like an industrial revolution was in the First World War, and like nuclear capacity was in the Second World War."[122]

Theo Francken, Belgium's defence minister speaking at the Drone Summit 2025 in Riga

UBIQUITOUS DRONE PRESENCE

The evolution of drone technology has reached a **critical inflection point, not by replacing human soldiers, but by becoming their organic extensions**. Drones are neither auxiliary assets nor dominant actors; instead, they are seamlessly embedded across every echelon of military operations, from squad level to strategic command.

Soldiers now operate in **close symbiosis with drones** through advanced interfaces such as augmented–reality (AR) headsets and neural–control systems, enabling intuitive, real–time coordination. Military effectiveness no longer hinges on the sheer number of drones deployed but on the sophistication of **human–machine integration**. Advantage belongs to the side that can integrate and interoperate fastest and most effectively. **Interoperability** of drone platforms, shared control protocols, and joint tactical frameworks are essential for maintaining operational superiority, while integration of drones across the entire DOTMLPF (doctrine, organisation, training, material, leadership and education, personnel, and facilities) spectrum is crucial.

Drone and counter–drone technological development, research, and procurement have become **integral** parts of military budgets, while training with drones is now **standard** for ordinary units. Army structures evolve as drone segments become embedded across all branches.

Human judgment and ethical accountability remain central, especially in high–stakes or morally ambiguous situations. Warfare thus becomes a hybrid of biological and digital intelligence, where humans are the anchor of responsibility.

Drones create near–total **battlefield transparency**, yet adversaries exploit it with multi–level physical and digital deception tactics. The battle **shifts from seeing more to knowing what to trust**, making perception itself a contested domain.

Logistics is transformed. Drones enable dynamic resupply and rapid mobility but also expose new vulnerabilities. The drone–dependent sustainment chain, reliant on battery packs, 3D–printed components, software updates, and secure data links, adds complexity to battlefield logistics. Supply chains increasingly resemble "code chains", where firmware control becomes a new logistics lifeline. Meanwhile, drones target supply routes deep behind the front lines, converting once–safe corridors into vulnerable zones. Ammunition, medical supplies, and civilian movements now face growing disruption. This pushes the logistics into the front line where key components are made **at the front line for the front line**.

While traditional military superiority still matters, it is now intertwined with the **resilience and adaptability of a nation's drone ecosystem**. Strategic advantage emerges from robust digital infrastructure, real–time ISR sharing, and joint swarm coordination. This underscores the urgency of reinforcing standardised systems, conducting joint counter–drone training, and implementing shared incident–management protocols. Dual–use industrial production is the new norm.

The future of warfare is **not drone–dominated, but drone–integrated**. Strategic cohesion and learning agility define the winning force.

"In today's warfare, you cannot win with yesterday's weapon. Today's warfare has to be fought with tomorrow's technology."[123]

General Anil Chauhan, chief of defence staff of India

SOFTWARE DEFINED FUTURE

The accelerated convergence of advanced robotics, autonomy, digital twins, and modelling with other emerging and disruptive technologies has **changed the mode of warfare**. It is defined by massive data streams, layers of sophisticated code, and multiple AI agents augmenting and supplementing humans in intelligence processing, planning, logistics, and even command.

Driven by the relentless pursuit of competitiveness, effectiveness, and dominance, militaries worldwide have adopted innovations, many inherently dual–use, originating in private innovation labs and commercial R&D clusters. Software–defined warfare sits at the intersection of the **civil and military domains**, further fusing them.

Expendability, reaction speed, precision, manoeuvrability, and emergent behaviours of autonomous unmanned systems enable **tactics and operations that traditional manned systems cannot achieve**. Moreover, AI–enabled C2 systems harness these capabilities to devise strategies that are often beyond human comprehension or feasibility, particularly in highspeed, complex, multi–domain operations. Such possibilities are both threatening and enticing for those seeking dominance in offensive operations.

At the same time, unmanned platforms can be deployed as adaptive air minefields and serve as backbone capability for defensive A2/AD strategies. Swarms of autonomous drones – launched in the air, on land, at sea, or underwater – operate even in EW–degraded environments. They prove to be highly versatile and effective across operational contexts. Military planners worldwide pursue the goal of fielding "intelligent mass". Beyond immediate battlefields, integrated AI applications are enabling predictive logistics management, advanced risk and casualty assessment, or enhanced planning models.

Even before perfected autonomous target recognition, tracking, and navigation are fully fused with distributed, AI–enabled C2 systems, it is evident that human decision–making is the bottleneck preventing the full realisation of **OODA–loop compression**. Against the backdrop of sharp strategic competition among major and regional powers, the incentives to shift from "human–in–the–loop" to "human–on–the–loop," and eventually to "human–out–of–the–loop," is strong. Implementing hybrid C2 architectures that fuse HITL, HOTL, and HOOTL designs is a central challenge for both allies and adversaries. Yet, as these technologies inevitably diffuse to actors unconstrained by ethics or law, the emergence of fully autonomous lethal weapons is becoming a matter of "when," not "if."

Software–defined warfare depends on massive **processing power**, **big data**, **human talent** and **institutions able to generate innovations**. Therefore, physical and cyber protection of data centres, access to advanced microchips, and cultivation of leading research and engineering talent, are treated as top national security priorities. Vital precondition is the ability to feed the ever–growing energy consumption back home and in the field. These assets are not only strategic enablers of software–defined warfare but also cornerstones of knowledge–based economic models. This requires a **grand strategy** integrating education, industrial policy, foreign policy, and national security into a coherent whole.

"Why is software so important? Because the next battles will be fought based on software supremacy. They really will be."[124]

Eric Schmidt, former Google CEO

POST–DRONE AGE

Once an asymmetric disruptor, the drone is now a **routine element** of warfare – predictable, countered, and strategically exhausted. Overuse, over–reliance, and effective countermeasures have eroded its utility, while political and societal backlash mark the start of a post–drone era. As history shows, every dominant technology gives way to the next. Drones no longer define warfare in the way they were widely believed to in the 2020s.

The post–drone battlefield is dominated by **counter–drone systems**. Sophisticated and multilayered defences have neutralised offensive drones through lasers, EMP pulses, and drone–killing drones, leading to heavy battlefield saturation. The low–altitude zone is overcrowded and unreliable, filled with decoys and interference, making the airspace difficult to use or contest.

Launching a drone now reveals its origin and path instantly, creating near–total **transparency of archers and arrows** which enables to anticipate drone attacks and counter them effectively. Iron Dome–type defences are now widespread. A balance of capability has emerged between defence and offence.

The international community is now imposing **strict limits on autonomous warfare**. Regulation stems from two converging forces: domestic pressure, as civilians demand protection from AI "killer bots," and an inflection point reached after mass–destruction swarm attacks. Terrorist attacks and mass casualty incidents drive global restraint. The result is a regime of tight **international control** and **ethical oversight**, comparable to bans on chemical or biological weapons. Autonomous targeting and drone swarms may be subject to stronger regulation or prohibition along with the AI and autonomous technologies, while micro and nanodrones are restricted to scientific use. Strict **no–drone zones** now cover cities, borders, and neutral territories, with only narrow corridors for commercial operations.

Export of critical parts, chips, and software is heavily monitored, and real–time **human oversight** for their use has become mandatory under international law. These measures mark a significant **shift from permissive innovation to enforced accountability**, driven less by technology itself than by fear of machines deciding who lives or dies.

In the first stages of this scenario, drones persist in support roles – intelligence, logistics, and reconnaissance – but their offensive use has become marginal, often limited to decoys masking missile strikes.

Breakthroughs now occur elsewhere: in quantum sensing, cognitive electronic warfare, AI integration, and enhanced infantry systems. Militaries have learned the importance of **multi–domain redundancy**, avoiding dependence on a single capability. As the low–altitude battlespace becomes saturated, strategic attention shifts upward – toward **high–altitude and orbital warfare**, where satellites, stratospheric platforms, and space–based assets define the new frontier. The future battlefield moves to space and the digital cloud, leaving drones abundant but strategically secondary.

The age of drone dominance has ended, giving way to a period of **restraint**, **regulation**, and **adaptation**. Transparency and human oversight have replaced secrecy and full automation, while deterrence limits reckless use. Militaries now spread the**ir focus across space, cyber, and** cognitive domains, transforming towards balanced qualitative military capabilities instead of quantitative supremacy in low–altitude zones.

**"I'm personally not convinced that the UAV business is as big as a lot of people think.
I believe that the UAV business could be a big bubble."**[125]

Armin Papperger, CEO of Rheinmetall AG

Chapter V – DRONE FUTURES

STRATEGIC IMPLICATIONS

Warfare is always intrinsically rooted in the technological, socio–economic, and political realities of a specific historical period. Living in the digital age, it is no coincidence that contemporary and future warfare is already – and increasingly will be – data and software driven. This will apply not only to peer to peer or near–peer wars but across the competition continuum. As drones remain a disruptive technology, the ongoing technological transformation will bring unmanned capabilities to the forefront, along with the fundamental challenges of AI, autonomy integration, and human–machine teaming. This shift will require balancing combat effectiveness with operational reliability and professional ethics. Beyond technological considerations, there are broader drone–related trends that will shape the security environment of NATO and introduce substantial political, societal and economic consequences. Together, the combination of technological progress and socio–economic and political responses will generate the following strategic implications:

A. **PROLIFERATION:** From persistent ISR, logistics, and electronic warfare to strike precision and lethality, various advanced capabilities – often originally civilian yet with high military utility – are narrowing capability asymmetry. While UAS lead today, unmanned platforms will undoubtedly spread to other operational domains causing similar disruptions as aerial drones. In addition, after a long time of technological dominance, leadership in a key disruptive technology is seriously challenged by actors beyond the Euro–Atlantic area. A key strategic question concerns the extent to which the spread of advanced unmanned technologies can be controlled, especially AI and autonomous capabilities and, in the longer term, potential applications of quantum and nanotechnologies.

B. **DEMOCRATISATION:** Due to the proliferation, the number of actors – both state and non–state, foreign and domestic – able to field advanced capabilities will continue to grow. For already fragile or weak states, this can lead to an even more lethal spiral of violence and subsequent waves of destabilisation spilling over national borders. Levelling the asymmetries can also result in regional shifts in balance of power and increasing power and influence of PMSCs. Therefore, the third drone era might be an era of persistent, fragmented, and decentralised violence, including in direct NATO neighbourhood, further augmenting the challenge of pervasive instability, as recognised by the NATO 2022 Strategic Concept.[126]

C. **HYPER HYBRIDISATION:** The defining characteristics of unmanned technologies position them to become the number one choice for below–threshold operations. The emergence of nanodrones, high–performance portable EW devices, drone–enabled hacking, psychological operations or border harassment are just a few examples of an ever–growing grey–zone toolbox. State–sponsored groups ranging from violent extremist cells and militias forming quasi–states to professional PMSCs are all likely actors in converging proxy and hybrid warfare. Besides major inter–state wars, internationalised, persistent, malign actions in grey zones may become a defining feature of upcoming decades.

D. **DETERRENCE EROSION:** Assessing emerging drone warfare, several strategic effects are apparent. First is coercion: deniable harassment is especially well–suited for below–threshold hybrid operations. Second is attrition: massing cheap platforms, saturation tactics, and unfavourable cost–exchange ratios for defenders are powerful attrition generators. Third is denial: ubiquitous ISR, superfast sensor–shooter cycle, swarms which translate into dramatically increased lethality and dense A2/AD bubbles. Sub–threshold coercion and cost–imposition–based attrition position drones as deterrence–eroding factors. Yet other forms of deployment might create denial effects that contribute to the overall deterrence posture. Looking specifically at defence and deterrence against unmanned weapon systems, the punishment option will likely remain problematic due to the attribution issue – raising the question of who should be punished — as well as the credibility of the threat, particularly regarding proportionality and escalation management. The denial option holds more potential, especially if the third drone age will generate solutions for multi–domain integration of “intelligent mass” and ubiquitous CUAS capabilities deployment within manageable cost–exchange ratios.

E. **LOWERING OF CONFLICT THRESHOLD:** The threshold for military engagement decreases through political considerations (limiting soldier exposure, fewer casualties, murky attribution, and precision leading to less collateral damage), economic factors (drones are cheap, with potential manpower reductions or restructuring), accessibility (dual use, proliferation), and asymmetry calculus (equalised capability gaps between various actors). On top of this, the risk of autonomous escalation through algorithmic decisions, misidentification, or autonomous counter–response loops will grow. In effect, persistent conflict, instability, and violence will feed into existing threats related to migration, extremism and terrorism both within the NATO and in its neighbourhood.

RECOMMENDATIONS

In the era of heightened strategic competition, integrating industrial, technological, foreign, and defence policies is a growing necessity. Given the high level of geopolitical and geoeconomic interdependence, the growing convergence of civilian and military domains, and the multi–directional relationships among suppliers, producers, and customers, a **shift from rigid strategies and organisational models towards an ecosystem–style approach** should be applied to ensure continuous adaptation, systemic resilience, and the cultivation of innovation as key properties of grand strategic considerations and policy drafting.

The rapid evolution of unmanned technology presents a major challenge for the highly regulated military–industrial complex, for the agility–and–adaptability–focused adjustments of DOTMLPF framework, and for international control regimes. The Alliance's **three core tasks**, as reaffirmed by the NATO 2022 Strategic Concept – deterrence and defence, crisis prevention and management, and cooperative security – remain valid and central to NATO action. But, as this report shows, drone adoption changes important elements in these areas, and the shifts triggered by emergence of drone warfare **need to be addressed**.

I. DETERRENCE AND DEFENCE

- **Rethink the capability development life cycle**

Employing an ecosystem perspective when rethinking the capability development life cycle should actively engage public–private partnership clusters – including software–oriented new entrants – to complement traditional defence stovepipes and achieve a shift towards an integrated military–civilian–industrial complex. The key ambition should be to maximise the shortening of the feedback loop between users (military), customers (procuring bodies), and producers (civ–mil industry) to ensure meeting the set requirements with best available capabilities through continuous adaptation. This should guide future investments in R&D, manufacturing strategies, and modernisation efforts.

To achieve the ability to quickly scale production in times of crisis or war, a new model combining multi–tier stockpiling (including critical raw materials, essential components, and modular parts) and sustaining stand–by/on–hold modular production capacities should be considered. Such an approach would mitigate the risk of stockpiling outdated platforms yet keeping the capacities to scale production if needed. This would also allow better focusing investments into innovation in times of peace and production in times of war.

- **Focus on agility and adaptability**

The upcoming diffusion of autonomy, the increasing presence of various unmanned platforms across all domains, and fielding of "intelligent mass" will inevitably increase pressure on transforming the DOTMLPF spectrum. Emerging trends point towards decentralisation of force structure, software defined capabilities, and network centric, AI–augmented C2 systems. For the Alliance, this presents both an opportunity and a challenge, especially for joint multi–domain operations. While specific DOTMLPF adjustments will be case–specific, the general principles that should guide reforms are integration, adaptability, and agility as key dominance enablers in an ever–changing environment.

- **Integrated counter–UAS defence**

Tiered responses should range from passive monitoring to active neutralisation and need to be integrated across the whole security system, including agreed tactics, techniques and procedures with clear rules of engagement to ensure responsible use of both drones and counter–drone measures.

Getting the integration of counter–UAS into overall air defence right will pose questions beyond strictly military considerations. Protection of critical infrastructure, borders and major public events will pose significant legal, administrative, technological, societal, economic and political challenges. No single institution – public or private – will be able to solve this alone.

II. CRISIS PREVENTION AND MANAGEMENT

Given the lowering conflict threshold, increasing conflict potential, and growing instability, the Alliance will face rising demand for crisis response, conflict management, and humanitarian operations in its immediate neighbourhood.

To promote regional security and meet emerging challenges, NATO should accelerate efforts in capacity–building, interoperability, education, training, joint exercises and promoting shared standards both for drone and counter–drone threats in its neighbourhood.

Drones can become part of the solution in conflict management by providing a perfect match of capabilities, fast deployment and lightweight footprint enabling quick response time and ease some of political dilemmas tied to operations abroad.

III. COOPERATIVE SECURITY

- **International legal framework and control regimes**

Uncontrolled proliferation of drones and related technologies can significantly contribute to the deterioration of the security environment and increase risks, particularly if proliferation extends from the quantitative to the qualitative level. The diffusion of AI, autonomy, and emerging technologies will have significant strategic and ethical consequences. NATO therefore should, in close cooperation with the EU, engage in shaping international control regimes and be actively present in global norm–building processes.

- **Extended partnerships**

Geopolitical and geoeconomic trends will place greater emphasis on cultivating new and existing partnerships. The drone age increases the demand for reliability and robustness of supply and value chains. Securing CRMs, supply chains, state–of–the–art manufacturing, and R&D should become a routine and integral part of NATO partnerships, joint capability projects, and international research cooperation. NATO should integrate these dimensions in existing formal structures (Partnership for Peace, Mediterranean Dialogue, Istanbul Cooperation Initiative) as well as within the framework of the Partners across the globe.

IV. PLANNING AND SEEING BEYOND HORIZONS

The NATO Science and Technology Strategy[127] rightly identifies foresight as one of the key objectives under its *Strategic Goal 1: Anticipate and Invest*, highlighting the need to expand the knowledge base beyond the traditional defence sector. This report aims to support that effort and defines the main elements of the anticipated third drone age. However, numerous areas covered by this report would deserve partial, topic–specific foresights – both technology–focused and broader–contextual ones.

In addition, future wars and conflicts will learn from current conflicts, and future wars will most likely be different. Therefore, strategic foresight should remain an iterative process, offering continuous guidance and updates to help the Alliance guide the uncertainty.

LIST OF ABBREVIATIONS

A2/AD – Anti Access/Area Denial

BVLOS – Beyond Visual Line of Sight

C2 – Command and Control

C4ISR – Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance

COTS – Commercial Off-The-Shelf

CRM – Critical Raw Materials

CUAS – Counter Unmanned Aircraft System

DOTMLPF – Doctrine, Organization, Training, Material, Leadership and Education, Personnel, and Facilities

EDT – Emerging and Disruptive Technology

EW – Electronic Warfare

FAA – Federal Aviation Administration

GNSS – Global Navigation Satellite System

HITL – Human-in-the-Loop

HOOTL – Human-out-of-the-Loop

HOTL – Human-on-the-Loop

IED – Improvised Explosive Device

ISR – Intelligence, Surveillance, Reconnaissance

MENA – Middle East and North Africa

MTCR – Missile Technology Control Regime

OODA – Observe Orient Decide Act

PESTLE – Political, Economic, Social, Technological, Legal, and Environmental

PMSC – Private Military and Security Company

SAM – Surface-to-AirMissile

UAS – Unmanned Aircraft System

UAV – Unmanned Aerial Vehicle

UCAV – Unmanned Combat Aerial Vehicle

UGV – Unmanned Ground Vehicle

USV – Unmanned Surface Vehicle

UUV – Unmanned Underwater Vehicle

VTOL – Vertical Take-Off and Landing

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