Air Force Global Futures Report

Joint Functions in 2040

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INTRODUCTION

When we design the future Air Force, we struggle with a key problem. The consensus view of the future is wrong. As humans, we are biased to believe that tomorrow is an extrapolated version of today. The problem is that these straightforward extrapolations limit our thinking and make us vulnerable to surprise. We tend to dismiss the possibility of surprise as we think about the future. This is true even when the events that surprise us are somewhat predictable through observable signals, even if those signals are faint. When we fail to recognize–or worse, dismiss–these signals, surprises will happen. Some are big, some not so much, but these surprises shape our future.

So what are we to do?

Fortunately, we can rely on a method of thinking–something we call "Foresight Methodology"–to help us pick important signals out of the noise. In the Air Force, we have applied this methodology to consider key forces and factors that will drive or constrain the future. This year, we are publishing our findings in the *Air Force Global Futures Report: Joint Functions in 2040.* In this report, we hope to disrupt our bias to linear thinking and encourage the use of Foresight Methodology as we consider our future. In doing this, we conduct systematic environmental scanning and issue analysis to uncover weak signals, current trends, and long-standing structural forces that together will shape the future.

In the report, we explore four alternative scenarios through the lens of the seven established Joint Functions found in U.S. doctrine (these are Fires, Protection, Movement and Maneuver, Information, Intelligence, Command and Control (C2), and Sustainment). Our writing team selected the Joint Functions to ground the future environments–which can sometimes be a bit abstract–to concrete challenges that are important across the Department of Defense and for allied and partner militaries. None of these alternative futures will perfectly predict what will happen, but they offer a range of possibilities that allow us to look for key insights across the spectrum.

For Tomorrow's Airmen!

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*The authors' views expressed in this document are their own and **do not** reflect official positions or endorsements of the Department of Defense or the Department of the Air Force.

EXECUTIVE SUMMARY

THE FOUR FUTURES

This report develops four alternative future operating environments (FOEs) through the lenses of continued growth, transformational, constrained, and collapse representations of the future in 2040. These global scenarios drew from **environmental scanning and issue analysis** that uncovered **emerging weak signals**, current **trends**, and long-standing **structural forces** that together will shape the future. There is no way to accurately predict the future given long time horizons and intervening events; this report instead provides an analytical assessment of potential FOEs, and through comparative analysis, raises key issues for further research. Using the four lenses, Air Force Futures examined the Joint Functions to demonstrate how emerging signals, trends, and forces may impact core operations across the USAF and DOD.

- Continued Growth: Great Power competitors continue attempts to increase leverage over the United States and diminish its advantages. Globalization remains the dominant economic factor, driving even more interconnectedness and interdependencies. Competitors make prudent economic choices to undermine U.S. alliances and partnerships and limit U.S. access to key resources and markets. Some competitors exploit ethical asymmetries to hollow out key treaties and international norms. Potential adversaries use proxy wars to test the abilities of genetically modified soldiers, advanced chemical and biological weapons, and nuclear weapons. Modern technology eliminates sanctuary, particularly when ubiquitous sensors incorporate artificial intelligence and machine learning (AI/ML).
- Transformational: Unprecedented technological advances and their widespread dissemination reshape global power dynamics on a scale not previously considered plausible. Revolutionary breakthroughs in gene editing and space capabilities—further enabled by advances in autonomy, AI/ML, point-of-origin manufacturing, quantum computing, and directed energy—disrupt the global security environment and lead to the development of weapons capable of instantaneous, world-altering effects.
- Constrained: Sino-Russian coordination continues to benefit both countries in everything from new technologies, strategic and critical minerals, to the mass production and distribution of resources. This cooperation bolsters their economies while blunting or destroying the economies of perceived rivals. New power blocs use gray-zone tactics and novel strategies to obviate great power risks and find opportunities to increase their own power. The United States and its Allies and partners struggle in this fractured world order.
- Collapse: Natural and man-made crises drive isolationist and nationalist tendencies globally. Relatively stronger countries protect their own interests at the direct expense of others. Weaker countries struggle to maintain order and provide essential service. Technological diffusion together with advances in quantum, autonomy, AI/ML, and directed energy has transformed warfighting while simultaneously collapsing the world order established in the mid-20th century. Increases in natural and humanitarian catastrophes add to tensions, as does the reemergence of powerful violent extremist organizations (VEOs) that step into the power vacuums. Reduced U.S. defense budgets lead to diminished military size and operational scope. Opportunistic competitors take actions to achieve nationalistic priorities and undermine the rules-based world order. Fragmentation and protectionism drive states to shore up resources and enact Orwellian controls on society.

STRATEGIC FORESIGHT

OVERVIEW

PURPOSE

Strategic foresight is the systematic study of the future to assist planners and strategists in anticipating what plausible futures may exist and allow them to steer organizations away from threats and toward preferred outcomes. Foresight ***does not provide predictions***; instead, it exists to improve decision making when predictive tools offer limited insights with low fidelity. Currently, predictive analytics do not deliver accurate and detailed predictions over the long term in environments that are highly volatile, uncertain, complex, and ambiguous (VUCA). The current global environment demonstrates increases across all aspects of the VUCA framework as technological speed, unprecedented information flows, shared worldwide challenges, dispersed and networked power structures, and interconnectedness reshape our world in profound ways. Accordingly, planning based on a singular vision of the future will prove insufficient as it fails to provide for potential rapid and dramatic shifts in the global operating environment.

Strategic foresight encourages anticipatory thinking to discover the edges of what is plausible and to prevent organizations from coalescing around a predetermined future. Failing to anticipate what could reasonably happen leads to missed opportunities, misallocated resources, and unmitigated vulnerabilities that cede advantages to others who seek to shape the world in their favor.

METHODOLOGY

The USAF's foresight method is a four-step process: (1) scan the environment for elements that may affect the future, (2) analyze those elements, (3) build scenarios based on trends and findings, and (4) analyze the scenarios and conduct exercises to examine where each environment provides challenges, opportunities, and risk to plans and strategies.

1. SCANNING THE ENVIRONMENT

Horizon Scanning generates inputs into the foresight process by identifying nascent indicators of change. The technique refocuses analysis inputs away from issues dominating the current environment to those just emerging in the field of view. A single scanning hit is a weak or **emerging signal** of change. Good scanning hits possess a significant potential to alter the future. A **trend** occurs when a series of scanning hits appear over time. Trends that are powerful, long term in nature, and stable in how they function are shaping or **structural forces**. Structural force examples include demographics, climate change, and globalization.

Trends progress along linear and nonlinear paths—some are simple S-curves, others are cyclical, and still others are outputs from chaotic and complex systems that appear highly erratic. Trends also converge in novel and unexpected ways, such as when a technology breakthrough leads to a new economic or social trend (*e.g.*, mobile apps). Accordingly, future and foresight activities will fail if they simply follow linear extrapolation of trends into the future and do not examine how trends impact each other.

Good scanning requires a broad view. To ensure broad horizon scanning, strategic foresight practitioners rely on scanning frameworks, often anchored in the macro-environmental factors of

political, economic, social, and technological (PEST) issues. Air Force Futures' modified standard methodologies for categorizing scanning hits and trends to develop its scanning framework categories: policy, economics, social, technology, life sciences, military, and cognition (PESTL-MC). It collected scanning hits from open sources, compiled the hits in a database, and binned them into PESTL-MC categories for analysis. It then identified trends when sufficient scanning hits emerged over time, and then down-selected key trends to move forward into trend analysis.

2. Trend Analysis

After compilation, the trends became inputs into sequenced **structured analytic techniques** (SATs) for analysis.[1] SATs are modular processes that provide repeatable and standardized methods used to approach problems, mitigate groupthink and biases, and provide divergent perspectives. Standard future and foresight practice require SATs that provide for Alternative Futures Analysis in order to inform Scenario-Based Planning exercises.

This report stems from six subsidiary events, either a single workshop or online working group, covering the seven Joint Functions. A single working group combined and analyzed the Intelligence and Information functions. The same sequence of SATs took place in both the workshops and working groups. The process began with Trend Clustering to identify interdependencies and locate new trends. Next, the working groups and workshops conducted a modified set of Alternative Analysis techniques to examine how different high-impact events may occur. The Alternative Analysis SATs purposely sought extreme positions (*i.e.*, poles) in order to broaden the spectrum of how each trend might manifest. The resulting scenarios therefore contain divergent views on how key trends will impact the future.

3. Scenario Building

Scenarios provide planners a variety of future operating environments to plan against, which increases readiness and helps to future-proof decision making. Scenario planning's pedigree is as old as warfare. War planners think through different plausible scenarios and examine possible courses of actions and contingencies. In long-term VUCA environments, scenarios provide foresight practitioners a means to convey complex future operating environments in a narrative form that is compelling and actionable. Scenarios provide linkages between trends and demonstrate how changes in one can create effects in another.

Air Force Futures selected and modified the Hawaii Research Center for Future Studies' ("the Mānoa School") Four Future Archetypes methodology to generate scenarios. The method is an industry-standard process that is easy to understand and leads to divergent visions of the future operating environment.

[1] For an in-depth treatment of Structured Analytic Techniques, see, "Richards J. Heuer Jr and Randolph H. Pherson, *Structured Analytic Techniques for Intelligence Analysis* (Thousand Oaks, CA: CQ Press, 2015)".

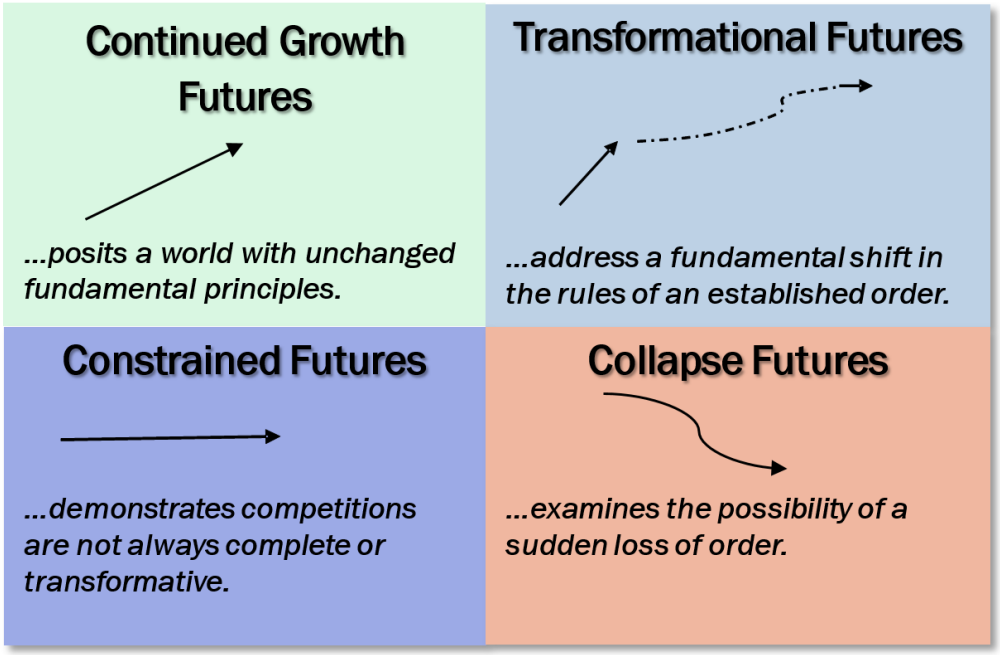


Fig. 1. Graphical representation of the Mānoa School "Four Future Archetypes" methodology

The Four Future Archetypes methodology produces four alternative futures: Continued Growth, Transformational, Constrained, and Collapse. As the future unfolds, a trend can either continue on its current trajectory (Continued Growth), encounter significant limits (Constrained), form a discontinuity to leap to a different market and growth curve (Transformational), or fail to adapt or become the cause of change (Collapse). **Importantly, the Four Archetype Method is not normative and *does not* suggest that any of the generic trajectories are either good or bad.**

Each of the Joint Functions working groups and workshops binned their major trends and alternative analysis results into at least one of the four archetypes. Accordingly, trends that participants deemed as significantly impacting continued growth were binned together, as were those seen as transformational, constrained, or demonstrating collapse. No trend and its direct alternative exist in the same archetype.

4. Scenario Analysis

This report consolidates the Joint Functions workshop and working group findings and narratives. It focuses on those emerging signals and trends that created significant effects (*see also* Appendices A and B). The four sections in this report each begins with a Global Environment that highlights shared features found in the workshops and working groups. Next, the report addresses key trends that uniquely affected each of the Joint Functions. This design allows readers to easily compare Joint Functions of interest across the four FOEs, and then to refer back to each global environment to see how the function of interest fits into a larger context.

This report is intended to be a starting point for analysis, not an end. Its takeaways suggest key insights and provide preliminary analysis learned from the Foresight process, but do not intend to suggest any definitive prescriptions. The report will be successful if readers develop new insights and understanding of how the future may exist and rid analytical processes of the notion that there is but one future. The report also seeks to support analysts, planners, and strategists in the identification of key trends and emerging signals that they can further examine and monitor.

Hubris warns that no entity can create the exact future it wants. However, organizations have a duty to discover opportunities and take advantage of them, make unforeseen disasters foreseeable and avoid them, and work diligently and disruptively to shape the future to their advantage. For the USAF and the DOD, the risk of a narrow vision and inaction is simply too high.

> System-changing, disruptive events are far more common than most people imagine… And yet most […] people behave as if they live in a continuous environment, as if their plans and business plans and projections are going to be relatively linear.
>
> PETER SCHWARTZ
>
> "Inevitable Surprises: Thinking Ahead in a Time of Turbulence"

FUTURE OPERATING ENVIRONMENTS

2040

CONTINUED GROWTH

THE GLOBAL ENVIRONMENT

By 2040, over 20 years of **great power competition** has led the United States toward increased tensions with great power competitors because of their expanded reach and influence around the globe. China and Russia continue to strengthen their position and influence in relation to the United States. They remain focused on undermining U.S. and Western influence and challenging the current **rules-based order**. Potential adversaries have infiltrated key aspects of U.S. business, technology development, academia, food production, energy sector, land acquisition, and entertainment to shape and influence the United States to align with their objectives. Direct superpower conflict has not yet occurred, mostly due to **deterrence** from the unacceptable costs of escalation.

Great power competitors have increased pressure on their partner states and those within their spheres of influence to diminish U.S. access. They have leveraged large investments to entice several former U.S.-friendly states to discontinue geostrategic basing and overflight arrangements. Other states, including China, have significantly limited or excluded Western access to parts of their markets. The West has adjusted to highly controlled export markets through expansion into developing countries across the Global South. Many states caught between the competing global powers have opted for a **non-alignment strategy**, attempting to play the great powers off each other to create internal wins.

The global great-power based realignment led to competition and occasional crises over key natural resources, such as critical minerals, energy sources, water, and food. Key resource **supply chains** have continued to grow highly globalized, fragile, and unsecured. These unmitigated vulnerabilities leave great power competitors and critical resource producers that seek their favor with the ability to hold U.S. interests at levels of risk that would have been intolerable in the early 2020s.

The concept of rule of law remains intact because **international governance bodies,** such as the World Trade Organization, remain important as economic arbiters. Concurrently, **ethical asymmetries** allow potential adversaries to flout core **security treaties** and legal regimes; these include the ban on the use of **chemical** and **biological weapons**, as potential adversary development of each continues to advance rapidly. **Alternative governance regimes** that benefit a Sino-centric world view have also gained significant traction as a means to weaken the West; for example, alternative banking structures arose that allow participants to bypass or obviate the oft-used cudgel of **U.S. sanctions**.

The great-power framework has escalated the frequency and intensity of **proxy war** as a means for great powers to demonstrate technological advancement and capability while draining focus and resources from competitors' core military functions. These wars have increased the likelihood for potential adversaries to operationalize the use of **nuclear weapons, hypersonics, and chemical and biological weapons**. (Game-changing advances in electromagnetic and directed energy weapons failed to materialize, and perpetually appear to be 10 years distant.) **Gene-editing techniques**, such as **CRISPR**,[2] that allow scientists to more easily, rapidly, and precisely modify DNA, have permitted state and non-state actors to experiment with **increasing performance** in intellect, strength, and stamina of warfighters. The threat of biological warfare has increased dramatically, but even in the wake of the pandemic in the early 2020s, funding streams for biological countermeasures and resilience have failed to keep pace.

[2] CRISPR stands for "Clustered Regularly Interspaced Short Palindromic Repeats." The report uses CRISPR broadly to refer to CRISPR-Cas9 and any other future gene-editing technologies.

Domestically, significant resistance to the use of U.S. forces in high-end conflict continues, in part due to the memories of the 20-year war in Afghanistan. Additionally, the U.S. military effectiveness in limiting both **military and civilian casualties** had conditioned the public to expect low losses, even as the foci of war shifted toward great power competitors that were significantly more powerful and lethal. The inability to reshape **risk tolerances** in the face of growing threats widened the gap between Public officials' expectations and military assessments. Furthermore, unchanging risk tolerances undermined capability and capacity development due to the zero-failure norms in the acquisition process and in the military industrial base. Public fear also led to strict limits in autonomy and automation; in the early 2030s, the U.S. became a signatory to a United Nations treaty requiring **humans in- or on-the-loop** in all tactical and operational military decision-making required for kinetic fires employment.

Military limits contrast sharply with global technology companies' successes in building out the "Three As"**: Artificial Intelligence (Narrow AI), Automation,** and **Autonomous Systems**. Self-driving cars, self-flying drones, and self-rolling robots ply the streets and airways of all major cities worldwide. The Three As accelerate efficiencies and optimized outcomes for areas such as technology research, complex problem solving, and logistics. The systems rely heavily on **integrated networks and sensors** in order to operate.

Due to proliferation of sensors, **almost no sanctuary** exists where commercial products cannot provide semi-persistent, multi-spectral monitoring. **Ubiquitous sensors** provide data for **Narrow AI** to sift through, together enabling the **internet of things**. People fulfill lower cognition tasks by simply allowing sensors coupled with AI/ML to predict their needs and either provide or guide them to solutions. AI/ML-linked medical and logistics sensors discover issues and remedy them before catastrophe, greatly **increasing life expectancy** to those with access and **longevity of goods**. Strong economic growth persists because of greater efficiencies, even in a world of increased geopolitical competition, diminished international market access, and aging populations in more advanced societies. Pernicious problems in information integrity persist as the fully-connected, big-tech dream has still failed to adequately address the incentives for creating mis-, dis-, and mal-information (**MDM information**).

Military applications of the "Three As" include **air domain persistence** via **semi-autonomous**, **long-endurance airborne systems**. The mixture of long-range and autonomous systems, coupled with Narrow AI optimization algorithms to run them, has increased the reach of weapons platforms and undermined potential adversary sanctuary. Expansive **advanced long-range strike platforms** rely on Narrow AI and ubiquitous sensors to enable **rapid kill chains** capable of simultaneously holding thousands of targets at risk. Ubiquitous sensors assist in creating unique opportunities and challenges for denial and deception for all sides in a conflict. Accordingly**, force posture and design** in the United States has continued focus on maximizing **dispersal** of assets to complicate potential adversary target calculus and maintain a credible force after an attack.

Cyber operations provide access in domains with limited physical access. World militaries often focus targeting on **supporting functions of military power**—such as communications and national economies—rather than on hard military targets. The U.S. maintains an edge in control of cyber and physical spaces due to investments made in cyber security including **zero-trust verifications,** granular data-aware security, and select uses of **quantum encryption**. For the first time, operational planning and execution are truly **all-domain** by necessity. Targets and weapon systems alike may exist in one or more of the physical, virtual, and electromagnetic dimensions. Long-range strike capability caused a shift in posture to smaller, dispersed basing structures. Disaggregation of forces led to added **complexity** to daily operations**. Reliance on remaining Allies and partners** is critical due to shared resources as well as the use of their domains for operations and global prepositioning.

Modern technology has eliminated sanctuary and allows for fine articulation of increasingly dispersed and lethal forces. Most actors have leveraged automation to conduct rapid operational planning, fight in contested environments, and maintain continuity of operations. However, even when data and technological parity exist, Western methods have an advantage due to competitors' reliance on less

sophisticated fusion methods and traditional hierarchies. Potential adversaries generally streamlined their existing procedures, while U.S. Allies and partners pivoted towards integrating effects to increase capability agility.

The world is more interconnected than ever as perceived advantages continue to outweigh the potential risks. To that end, the issues of major interdependencies that emerged during times of increased tension remained unsolved. The United States and its Allies and partners continue their reliance on external resources to meet domestic needs. This sustained dependence leaves unmitigated vulnerabilities that competitors exploit when tensions rise. In sum, the United States and its Allies and partners remain competitive against great power competitors in most metrics of power, but advantages seen 20 years ago have largely disappeared.

THE JOINT FUNCTIONS

FIRES

Advances of **kinetic** and **non-kinetic weapons** have confirmed sanctuary is a myth; no place is safe from attack. State and non-state actors are now able to hold key segments of the U.S. national security apparatus at risk through **offensive cyber operations, advanced long-range strike** (*e.g.*, hypersonics), and significant increases to strategic arsenals. For example, by 2040, China's mobile **nuclear and conventional hypersonic platforms** bear munitions that have the **mass and precision** to evade U.S. defenses. Additionally, potential adversaries have invested heavily in capabilities to enhance cyber and non-kinetics fires, greatly expanding their reach and power. Likewise, advancement in U.S. fire capability remove sanctuary from potential adversaries and further complicate their military operations and strategies.

Fires capabilities have continued to diversify with a mix of mobile, highly exquisite weapons proliferated globally as well as attritable, unmanned systems that act as a **blend of both platforms and munitions**. Quantity has increased in order to stack effects and generate mass. Munitions and platforms are more reliant on advanced command and control (C2) to allow for interactions and targeting with humans in- or on-the-loop. Accordingly, massed fires are more accurate, autonomous, and lethal.

PROTECTION

Interoperability with Allies and partners and force posture rely upon secure cyber and logistics networks. U.S. research in quantum encryption enables select network security in key facilities and **hardening of resilient logistical supply lines.** Physical defenses have not kept pace with **kinetic countermeasures**, such as **airborne autonomous systems** and **advanced swarm technology**. The DOD remains vulnerable to supply chain issues, particularly with regards to critical minerals for key components. The lack of wartime-reliable means of manufacturing and maintaining platforms and munitions has only expanded U.S. vulnerability in the face of rising alternative power structures.

Even with autonomous countermeasures, active protection capabilities are inadequate to address the array and depth of potential adversaries' long-range strike weapons due to U.S. prioritization of legacy platforms and munitions. The majority of bases in 2040 are left vulnerable and with insufficient missile protection. Joint bases that are co-located can share in a system-of-system protection web, however, these active protection assets have not been effectively optimized due to competing Joint Force priorities. **Advanced sensor capabilities** and **Narrow AI** help address gaps in tracking and targeting that were left vulnerable by the continued use of outdated Patriot and Terminal High Altitude Area Defense (THAAD) systems.

MOVEMENT AND MANEUVER

Competitor pressures have complicated **access, basing, and overflight (ABO), force posture,** and global logistics. Finding the correct mix of old and new technology allows militaries to restructure forces in an environment of limited ABO. For example, electric jets for long-distance air travel have failed to materialize, limiting speed and distance of electric aircraft. Accordingly, the **energy mix** for fuel is split between electric and combustible depending on mission needs, with electric motors powering short distance journeys (especially **runway independent** ones) and fuel-efficient, liquid fuel-powered vehicles accounting for long distance or high-speed trips.

Autonomous collaborative platforms have become standard companions in combat missions with manned aircraft, increasing awareness of the battlespace. They simultaneously provide critical support while airborne and are able to operate in risk environments deemed unacceptable to humans. Autonomous systems are also highly desirable as they can maneuver in manners and in such numbers that offset potential adversary defenses. The use of autonomous systems has also increased in space, which has expanded its role as a key grounds for achieving and contesting movement and maneuver.

Movement and maneuver concepts have expanded well beyond the physical world and into the cyber and cognitive realms—particularly where **information systems interact with human decision making.** As speed in the cyber and cognitive battlespace becomes a greater determining factor, new concepts emerge on how to outmaneuver potential adversaries in a non-physical domain.

INFORMATION AND INTELLIGENCE

Over 20 years, major media companies continued their decline, as **dispersed and networked emergent media** became even more prominent. In public discourse, the line between **information and intelligence blurred** as those on the edge who gathered the information immediately provided their own analysis during its release.

As the fight for the **attention economy** grew more intense, so did the overwhelming nature of content. Information providers' perverse incentives for views, ratings, and interactions led to an unrelenting, self-perpetuating ecosystem designed to uncover or fabricate extreme versions of reality. With broadcast turning toward **intercast** (media directly from network user to network user), issues emerged from the complexity of a system that shaped the facts of the story based on its own limited incentives for more attention. The networked intercasts have polarized the masses and have created niche environments in both the remaining broadcast entities and social media platforms.

The Intelligence Community (IC) continues to grapple with filtering the vast amount of manufactured information released into the connected **internet of things** environment. The proliferation of botnets, **deep fakes**, and social engineering campaigns from a variety of malicious actors blurs the line between reality and fiction. Information is abundant, but much is false or insignificant; the ability to analyze and validate information is paramount to producing sound intelligence. Advances in **data encryption, storage, and transmission** as well as **exquisite sensors** and reliable **human intelligence** sources have helped the United States maintain an advantage over potential adversaries in the information and intelligence Joint Functions.

Two lines of effort arose with the intent to stop the proliferation of false information and produce authentic, **verifiable intelligence**. The first line of effort sought technologically advanced systems to protect, store, and transmit both the valid information and the verified intelligence. Advances in **encryption**, including **quantum encryption**, have allowed increased secure transmission. Development of **blockchain** and **synthetic, biologically based data storage** allows a verifiable means to store and share information and

intelligence between approved agencies and clients. **Narrow AI** helps maintain security through **layered advanced biometric authentication** that have remained resistant to deep fakes; methods include voice printing, body movement recognition software, and pattern-of-life verifications. The second effort to create verifiable intelligence is a "back to basics" approach that uses a mix of exquisite sensors and human intelligence. In many ways, the human ability to gain information and interpret its significance to generate an advantage remains the gold standard for intelligence, and has increased in value. Accordingly, **loss or compromise of human intelligence sources** have become more significant in an era where verifiable intelligence often requires human skills.

COMMAND AND CONTROL (C2)

Despite similar levels of technological advancement to great power competitors, the United States and its Allies and partners currently maintain an edge thanks to novel adaptations in the command and control of forces and a focus on resilient communication architecture. Near **universal network compatibility** allows for a bespoke approach to information sharing at the strategic level. Thanks to the negligible **cost of storage**, meta-tagged information can rapidly be cross-cued against other sources to reject bad information. Concerns about runaway automation prevented full optimization of AI-enabled command and control systems.

The current automation produces optimized courses of action (COAs) to deliver desired effects within **acceptable levels of risk** (ALR). Commanders and their planners transmit orders through secure channels via distributed communication nodes. On the receiving end, tasked units conduct local planning using similar automated means. Warfighting experience in low-intensity conflict indicates these methods will work at scale to generate tempo faster than potential adversaries can respond.

Changes in tactical C2 methods are the most radical where **alternative power structures** have emerged to retain talent. The USAF has delegated decision making to levels commensurate with acceptable levels of risk. Dispersed teams can operate almost anywhere, coming on- and offline as needed. Low-probability intercept (LPI) methods and fused tactical intelligence disrupt enemy targeting before nodes can be located. Operators process information using sensory cues in physical, virtual, and augmented reality workspaces, allowing them to **integrate fires across domains to overcome tactical defensive superiority**. This sometimes involves taking direct control of remote assets. Breakthroughs cannot always be exploited due to horizontal and vertical escalation fears, but iterative planning reduces kill chain prosecution time and friction between joint forces.

SUSTAINMENT

Increased proxy wars focus efforts on expeditionary missions in austere environments that require **remote self-sustainment**. Services incorporate mobile, **additive-manufacturing** equipment. Civil engineers can reach back to home base for support and build basic infrastructure, such as runways and shelters, with reduced on-site manpower requirements. Resource limitations require delivery of large amounts of raw materials, accomplished through pre-positioned sea and/or surface methods. Life sustainment is critical to standing up mission sites in austere locations and modern additive manufacturing can provide soldiers with food, water, and shelter given only the proper basic ingredients.

Interoperability has increased due to the open and common IT architecture that includes Allies and partners. Release of key patents for compatibility and interchangeability of parts has enabled mass production. International compatibility standards have also improved, making systems more interconnected and secure.

Pulsed and pushed **swarming logistics** (*e.g.*, massed drone delivery) have proven key in campaign success. Technological factors that lead to wins include the incorporation of autonomous asset tracking that is directly linked to order and shipping tracing. Digital protection of supply lines are bound to the physical protection of the personnel operating them, as well as the security of the autonomous material loaders and intra-theater airlift autonomous collaborative platforms. Autonomous cargo land vehicles and ships also enable large scale operations with **reduced manpower**.

TRANSFORMATIONAL

THE GLOBAL ENVIRONMENT

By 2040, technology reshaped global power dynamics on a scale not previously considered plausible due to its unprecedented advances and wide-spread dissemination. Revolutionary breakthroughs in **genetic editing and space capabilities**—further enabled by advances in **autonomy, AI/ML, point-of-origin manufacturing, and directed energy**—disrupted the security environment and led to the development of weaponry that, if used, could create instantaneous, world order-altering effects.

Space-based instant strike capability has led to the complete **erasure of sanctuary**. The minutes between the launch of strategic kinetic weapons and impact have been reduced to seconds. Great powers operate with significantly reduced margins of safety and threat of first use looms large. Treaties prohibiting space strikes involving nuclear and other weapons of mass destruction evaporated when potential adversaries accelerated directed energy programs and placed the weapons in low-earth orbit.

In addition to space, significant developments have taken place in harnessing the power of the genome and altering it. Enhancements in gene-editing technology (*e.g.*, CRISPR) have been perverted into **new weapons of mass destruction**. These genetic weapons can both target or spare specific populations. The effects can be varied depending on the desired outcome of the weapon employment. While **laws against genocide** and **bioweapons** prohibit the usage of such armaments, development still occurred due to increased desire of potential adversaries for strong deterrent capabilities and Western needs to develop effective countermeasures.

With weapons too lethal and precise to be used overtly, **gray-zone** conflicts persist. Rogue states developed and deployed discreet bioweapons tailored to devastate livestock and/or fauna in order to displace populations or devastate food supplies. **AI/ML-augmented decision tools** can determine the ideal desired effect for a conflict outcome and then miniaturized, portable CRISPR labs are able to mass-produce the weapon in the field near the site of employment. Many suspect that rogue states have developed and tested this capability on a small scale, but it is nearly impossible to trace the origin of these weapons and attribute them to an actor. The new gray-zone arms race has also drawn disdain from the international community and those states without the capability have minimal chance of countering the devastation if these weapons are employed.

In some ways, the transformative weapons of **directed energy and bio-engineered attacks** led to a stronger defensive posture, and one which gave the U.S. and its Allies and partners an edge due to their prior expansive global reach. The world now resembles something akin to the Cold War, with **large blocs of states** working together against competing forces. The power of the potential adversary is great enough to drive interoperability and codependence within their blocs. While the walls grow ever higher against geostrategic competitors, those between Allies and partners disappear. Global, fully integrated military systems bolster strong relationships between the United States and its Allies and partners. This includes complete **value chain integration** of all intellectual property, components, parts, and materials. The **change toward a non-expeditionary posture**—enabled by changes in law and policy—has led to increased **interdependencies on Allies and partners** for access and support of a Combined Force in distant locations. **Interdependence**, **interchangeability**, and **interoperability** have become the mantra of all systems and platforms.

Developments in **directed energy, space-based strike,** and **biological weapons** have led the USAF to shift away from **dispersed approaches to operations** and to reconsolidate the force into a **smaller, hardened, and more self-sufficient** footprint. Consolidated locations allowed for immediate countermeasures through the usage of biological and directed energy sensing. **Base realignments and closures (BRACs)** began in

earnest in the 2030s in response to the advent of Chinese directed energy. Mothballed Cold War locations were brought back to fully operational status while high-risk overseas locations within easy range of competitor systems were decommissioned.

The United States remains dominant in **space** and **cyber**, thanks to continued support from Allies and partners. The U.S. Space Force has hardened assets and increased countermeasure capabilities, making satellite arrays and other platforms a safer place to store essential communications; position, navigation, and timing (PNT) arrays; and even low-altitude cargo for resupply. The consolidated terrestrial bases of the U.S. and its global Allies and partners provide sufficient launch positions to support space operations if conflict arises and to transfer critical supplies anywhere using space for mobility.

On the cyber front, federated cyber teams and worldwide fusion cells proactively disrupt and deny attacks before they reach U.S. systems. **Preemptive cyber denial** resulted from changes made to the architecture of the internet. Malicious cyber activity on U.S. economic targets led to increased **balkanization of the internet.** The "splinternet" has aided the ability of the U.S. and its Allies and partners to address a variety of information and cyber warfare vulnerabilities as major information campaigns are now detected through new sourcing methods and tamped down early.

The cyber realm has also changed in both **speed and complexity**. Human thinking is inextricably reliant on machines as anyone under 50-years-old is a digital native. Militaries focus resources on **systematized and exactly sequenced cyber and cyber-enabled operations**, which are conducted at speeds that do not allow for significant modifications after commanders select a course of action. Accordingly, extensive *ad hoc* wargaming, legal oversight, complexity-based collateral damage assessments, and other critical decision inputs are required before such operations are launched. In sum, the speed of the cyber world concentrates operations left of an action, as human reaction time no longer provides decision advantage in the battlespace.

Low-cost energy is more prevalent and catalyzed changes across the world. The breakthroughs have allowed for expansive electric energy infrastructure to spread across the globe. The new **energy web** not only powers terrestrial vehicles—such as electric trucking fleets, personal vehicles, and autonomous delivery robots—but has also expanded to sea, air, and space domains. Military-grade, rapidly deployable systems provide capabilities for new energy routes. Electric aircraft and vessels (both autonomous and human-driven) that use this energy web no longer face fossil fuel shortages, allowing for massive dispersed operations *en masse* to anywhere connected to an ocean. The electric web has enabled next generation **high-speed vertical takeoff and landing platforms (HSVTOLs),** which have transformed both force distribution and dispersal as well as **ABO.** Runway independence has become the norm in austere environments and HSVTOLs return to the consolidated basing structure only for repairs and special cases. Traditional main operating bases are still necessary for long-term scheduled maintenance and force protection.

Quantum-enabled AI/ML has empowered sophisticated militaries to make significant advances in materials sciences allowing advanced **additive manufacturing** both at home stations and contingency locations. The ability to parallel process tens of thousands of modeling simulations in near-real-time (NRT) has enabled transformational changes to AI/ML and decision making. The military has embraced **high task automation, taking humans out of the loop.** Nearly all iterative learning control-type tasks—such as flight or maintenance scheduling—have turned to automated predictive maintenance and anticipatory supply chain management. AI/ML-enabled systems predict when components in any system will fail and preemptively plan for replacements. The networked automation efforts replaced humans in many complicated tasks while decreasing force size and altering airmen's job duties and requirements.

Quantum supremacy has ushered in a new era of communications and **cyber and network security**. The ability to cluster distributed quantum computers creates both a robust and resilient self-healing supercomputer mesh network with exponentially more computing power at the edge. Extremely high

storage capacity allows contractors and the military to hyper-metatag every aspect of daily operation with **strong information veracity** to a federated database. Reliable, securable cloud-based data is available on-demand on any device and on any security echelon anywhere in the world.

Quantum networking has also enabled discovery in biological data processing. **Novel biological-based information** storage, sharing, and retrieval allows for humans and machine to interact more seamlessly, allowing control of digital and physical objects through thought alone. Scientific breakthroughs in advanced **human-machine interfaces** combined with **synthetic biology** allow cognitive researchers to see the formation of thoughts in real-time. **Biometrics** and **advanced sensors** have enabled **advanced lie detection** technologies. The ability to uncover subjective truth from deceptive individuals has created a new era in information and intelligence with confidence in the objective truth as the center point. As with space fires and bio-weapons, states and organizations genuinely concerned with human rights have pushed back. After years of debate, state parties permitted an exception for global security forces and intelligence agencies to an international treaty banning the use of suites of technologies for "the purposeful manipulation of nascent human thought" and "the monitoring and detection of human intentionality prior to actions."

Metaverses merge aspects of digital and physical domains into a fully immersive, virtual space. Digital denizens transcend national borders and **weaken national identities** while increasing core interest-group identities. For high-end users, the synthetic biological linkages to the system provide a new form of reality and cognitive feedback that fundamentally alter how they control and operate in virtual and cyber spaces. The physical world's **universal federated sensing web** allows for direct replication of the physical environment in the virtual space; and those in the physical space use augmented reality sensors (*e.g.*, smart glasses) to interact with their virtual counterparts. Privacy concerns have extended similar property and rights protections to the virtual spaces as found in physical ones, which has complicated military, law enforcement, and intelligence activities. Metaverses have provided continued global interconnection even with increasing cyber balkanization. Due to the economic incentives to participate in the virtual space, almost all countries engage to the degree allowed subject to their national laws, regulations, and firewalls.

The quantity and spread of new technologies have created significant polarization in **civilian-military relationships**. Metaverses and access to the **universal federated sensing web** pose significant legal challenges and barriers to quantum-enabled warfare. Hybrid warfare includes economic disruptions coupled with broad use of MDM warfare against civilians. Domestically and internationally, these operations have led to a civilian-military schism and altered many countries' doctrinal definitions of warfare. Both civilians and militaries continuously debate on the scope and scale of the battlespace as policy lags behind exponentially growing technology adoption.

Military-industry relationships have become strengthened and synergized to address rapid changes in technology through highly responsive and agile acquisition processes. In key areas, the military has embraced a **novel pay-as-you-use** construct for many types of **asset ownership.** This facilitated lower-cost, rapid, on-demand upgradability via automated digital updates. The military leases and operates continuously evolving platforms with subscription-based capabilities, which allows for increased role and mission flexibility as emerging requirements drive technological advancement.

In sum, the scientific breakthroughs at the macro-level (space) and the micro-level (biologic, quantum) coupled with additive manufacturing and other digital and technological advances have created a volatile mix of capabilities that significantly add to the existential threats the human population faces on the planet.

THE JOINT FUNCTIONS

FIRES

Additive and point of origin manufacturing have developed to where militaries can "print" weapon components from raw materials in a matter of hours anywhere on the globe or in orbit. **Global powers** can field orbital factories that create **space-launched munitions**, including **hypersonic weapons**, capable of hitting targets moments after their creation. In addition to being created quickly, autonomous systems can employ these munitions and assess and select targets with speed due to **quantum computing** breakthroughs**.** The result is an ability to quickly produce mass fires that can precisely hit autonomously selected targets within seconds with little to no advanced warning of platform positioning. Additionally, states pulled out of the Outer Space Treaty of 1967 and the resulting storage of nuclear warheads in space has increased global fear of rapid strike capabilities, critically reducing reaction time. Not only are revolutionary space-based kinetic weapons available, but space-based, non-kinetic, **directed energy weapons** augment ground-based, anti-access and area denial (A2/AD) capabilities.

New space capabilities allow the United States and great power competitors to engage targets in a space-to-surface or subsurface (*e.g*, undersea) manner. These "all-seeing eye" platforms monitor and mitigate threats with only limited need for human input or authority. Systems have been created to collect and focus near limitless **solar energy and cosmic radiation** with devastating accuracy and precision.

PROTECTION

The 2040 approach includes **fewer bases**, which limit **logistics tails** and munitions distribution challenges. Dramatic advancements in **additive manufacturing** also enable production of key components on demand. A non-expeditionary posture allows for longer airstrips and continued usage of legacy aircraft. **Small, unmanned autonomous platforms (UAPs)** are employed to quickly load and unload materiel on **interoperable systems** that are built to the same standardized designs. **Small aerial UAPs** can also be tasked as a part of an airborne weapons layer (AWL) defense structure.

The concept of **integrated layered defense** evolved into shared defense where Allies and partners shared capacity for manufacturing and dissemination of interoperable materiel (thanks initially to the spread of **additive manufacturing**). Shared defense required **retraining of airmen** to adapt to the shifted cultural understandings, especially where Allied and partner commanders were in charge of **combined bases**. Through **integrated** supply chains, personnel, and interoperability of systems, Allies and partners have become critical in generating power from U.S. held locations just as U.S. forces have become essential in supporting Allied and partner positions. Basing and overflight access are nearly unconditional as both economic and military ties have deepened. Ensuring access to key natural resources for force protection also becomes paramount.

MOVEMENT AND MANEUVER

Electricity generating stations dot every major shipping channel around the globe and provide rapid electric bunkering. The same stations also host fleets of autonomous flying batteries which can rapidly ascend to altitude to refuel passing **electric aircraft**.

While the cargo capacity of many electric systems is small, the overall effect of dispersed transport revolutionizes how and where militaries can send equipment and personnel. The dispersed nature of the

system decreases vulnerability of individual large transport vehicles and alters calculations on overall operational speed as it removes individual vehicle loading and unloading times while benefiting from flight speeds of air transport. Key high-speed systems still require liquid fuels and are chiefly employed for space operations or other operational requirements where immediacy is critical.

The energy web has enabled **directed energy weapons**, complicating movement and maneuver**.** Lack of concentrated forces in the field has proved necessary as **extreme standoff capabilities** based in or on land, sea, space, and underwater domains have gravely limited the ability to conduct traditional movement and maneuver operations. Conducting effective operations in modern operations relies on **mass** that overwhelms adversary systems as well as rapid repositioning of extreme standoff assets into the contested environment.

INFORMATION AND INTELLIGENCE

A significant portion of the global population experience their reality in virtual environments. Accordingly, digital artifice has replaced or augmented physical experiences. The need increased for an entity that could parse truth from fiction and genuine information from false or misleading MDM information. Globally-integrated intelligence communities (GIICs) became the preferred option. GIICs' ability to get to the truth of the matter allows them to fight back against malign next-generation, integrated information campaigns. Trusted GIICs have taken on the role of **arbiters of truth**. Externally facing agencies directly inform the public on issues of critical importance to national security through new open-source fusion intelligence (OSINT) distribution centers.

With a monopoly on truth assessment software, GIICs have increased in power, stature, and importance. Even so, the blurry line between virtual and physical spaces has altered legal doctrine. In the United States, the increase in digital privacy rights and the erosion of national identities has changed intelligence collections' methods and scope due, in part, to the bans on warrantless collections against U.S. citizens.

The complexity of the new information environment and speed of action and interaction has pushed GIICs to follow a bottom-up approach and to **prioritize tactical intelligence** that accumulates to inform larger strategic priorities. The bottom-up approach to emerging issues allows for rapid response to address potential threats preemptively and adapt strategy quickly. The ability to rapidly analyze and respond to issues has altered the how GIICs operate and their willingness to engage in the digital space with new means and methods of information collection and intelligence distribution.

COMMAND AND CONTROL (C2)

Between anticipatory supply chain management and additive manufacturing, it is no longer necessary to plan, pack, and transport as many redundant parts across the any operational theatre, shrinking the "tyranny of distance" for Adaptive Operations in a Contested Environment (AOiCE). Access to **AI/ML enhanced C2 networks** facilitates **decentralization command** and allows for distributed control. The advent of quantum computing enhancing AI/ML has dramatically amplified the decision-making process by digitally iterating thousands of possible outcomes in seconds. Quantum supremacy has been key to the changing the mentality that command and control are inseparable terms and has further enabled authority delegation of both command and control to the lowest appropriate echelons, compatible with ever-changing acceptable levels of risk.

Almost all devices and sensors connected to separate regions of the internet are consolidated into a system where data is commercially scraped, meta-tagged, filtered and aggregated to aid in rapid, "intelligentized" decision-making. Additionally, the military's access to such adaptive ownership models enables **seamless connections with legacy and next generation C2 systems.**

SUSTAINMENT

Ground-based weapons systems exist as almost completely self-sustaining systems due to self-diagnostic integration with direct inputs to additive manufacturing capabilities for producing replacement parts. The evolution of **nanotechnology** increased functional capabilities and capacities of single airframes. This enabled certain tasks to have multiple redundancies without impacting weapons systems performance. One of the United States' leading advantages are airborne weapons systems with hybrid energy propulsion. Self-sustainment and increased redundancies decrease the strain that was previously placed on sustainment and energy systems. The energy web has dramatically altered the need for liquid fuel distribution.

The sensing grid enables the ability to calculate, plan, and produce optimal solutions for source material, repair options, and locations to restore assets back to mission-ready status. Metaverses and augmented reality enable long-distance interactions and immersive means of diagnosing and understanding systems.

CONSTRAINED

THE GLOBAL ENVIRONMENT

A 20-year-decline in **access to natural resources** has challenged the United States' ability to project global power. Commodity and **energy prices** soared due to worldwide tensions that began with the Russian invasion of Ukraine in 2022 and a PRC partial blockade of the South China Sea in 2028. East-West relations have turned cold over increasing **sanctions** and **polarization** between the free world and states sympathetic to Sino-Russian claims. Fluctuations in annual temperatures have strained **global food production** and changed the Arctic landscape. Melting ice opened northern littoral passages which have become important geostrategic transportation corridors that have brought new challenges to homeland security in North America.

Domestically, the global **COVID pandemics** of the early-and-mid 2020s have resulted in numerous **chronic health issues** in the U.S. population and has stressed the health system almost to the point of failure. The **U.S. economy** continues to decline and **partisan** bickering worsens as the country edges further apart. As a whole, these internal challenges have motivated the United States to further withdraw from its role as a global leader.

Climate change and the natural resources competition (*e.g.*, for **strategic and critical minerals)** has increased tensions throughout the world. As an offset to the global powers, **regional defense blocs** akin to **NATO** have sprung up in South America, Asia, and Africa. These blocs act as buffers against (and sometimes participants in) direct military interventions and **gray-zone warfare** attacks. Unaligned, weaker states with profitable resources or strategic positions will increasingly face the threat of advanced gray-zone attacks or proxy wars. For example, due to resource scarcity and national power projection, increasingly violent open water commercial fishing skirmishes and **piracy** emerged in economic exclusion zones, particularly across Southeast Asia, the Horn of Africa, and Gulf of Guinea.

The proliferation of **exquisite A2/AD** systems significantly challenged freedom of navigation through major trade routes in the Pacific. Political reticence stops the U.S. military from fully utilizing automated A2/AD defenses due to the long-lasting risks borne by innocent civilians. Competitors face no such restrictions. Additionally, potential adversaries' threatened use of **precision bioweapons** has eroded and halted many U.S. military actions and undermined the ability to effectively project power.

U.S. competitor stockpiles of **exquisite long-range fires** led the USAF to disperse its forces on a regular basis from large and centralized bases to clusters of smaller distributed locations, both globally and, to varying degrees, in the Homeland. While **dispersion** offered to offset risks against long range fires, it reduced efficiency, and levied additional resource and manpower demands on an increasingly constrained force. Simultaneously, waning **civil-military relations** and **political polarization** in the United States led to reduced budgets for military forces and pay freezes, which in turn increased **competition for skilled human capital** with the private sector.

Great Power tensions and advanced weapons technology competition has shifted into a perpetual stalemate, similar to WWI, except the trenches are now the oceans. In this world of extreme A2/AD and mutually instantaneous assured destruction (MIAD), those willing to push their weight around below the threshold of armed conflict have banded together to find advantages they would not possess alone. Gray-zone warfare has accelerated and metastasized; it favors smaller states or blocs seeking to disrupt and increase their equities in the global power structure.

This crisis-inducing, multi-domain gray-zone effort lends itself to those with **ethical, societal, and technological asymmetries**—including **Chinese and Russian collaboration** against Western **democracies** and regional rivals. **Great Powers**, non-state actors, and smaller state competitors' successful use of malign influence campaigns has caused other state and non-state actors to ramp up their efforts and attacks. For example, intensive **worldwide hacking** by state and non-state actors contributes to social unrest and financial challenges due to attacks on core infrastructure and logistics pipelines *(e.g.*, supply chains, medical care, banking, social media, public utilities, etc.). Journalists disappear regularly, as do people anywhere on the globe who create sufficient resistance to authoritarian regimes.

Potential adversaries have increased the variety of their **bioweapons,** specifically targeting warfighters. Military and civilian medical databases are prime hacking targets and recruitment rates have dropped sharply due to fear of long-term health issues. The already strained U.S. medical system cannot support U.S. military needs. The United States has teamed with Allies and partners in the interim to provide medical care and treatments, but the lack of funding makes it impossible for this to continue long-term. Lack of medical care increases **distrust** within the military that further undermines military readiness.

U.S. readiness for countering insurgency and gray-zone operations has decreased as it pivoted to high-end exquisite capability development *(e.g.*, directed energy and hypersonics) for global competition and conflict. With extensive domestic unrest, the United States is generally unprepared for the emergence of next generation gray-zone warfare that freely targets civilian populations, so long as the first-order effect created is non-lethal. Arguments erupt over persistent attacks on soft targets and ineffectual government responses to civilian collateral impacts, many of them financial. The country further polarizes between those trying to ethically fight the upheavals and attacks on the U.S. way of life and those who demand the U.S. respond in kind through intensive influence operations, malicious cyber activity disrupting electrical grids, and other retributive means.

An inability for the DOD and IC to combat nefarious gray-zone **information operations** actors stems largely from **cost** and **policy constraints**. Increasing costs for advanced technologies needed to fight the rise of MDM information combined with tight budgets has made it difficult to keep up with corporate, non-state, and state sponsored agents proliferating falsehoods in attempt to change behaviors. Similarly, neither law nor policy has kept up with the changing information and technology environment. This has led to an **inability to utilize key technology advancements** developed in the private sector on government owned systems for fighting information operations or conducting other IC needs. Corporations and competitors without these limits are able to outpace the intelligence and defense agencies in adoption of technological advances to turn information into usable intelligence. This places U.S. governmental agencies at an information disadvantage in **speed of analysis**.

In sum, the Sino-Russian coordination continues to benefit both countries, in everything from new technologies, rare earth and other high-demand elements, mass production and distribution of weapons, to bolstering their economies while hindering and destroying the economies of perceived rivals. New blocs and potential adversaries use gray-zone tactics and emerging strategies to obviate great power risks and find opportunities to increase their own power. The United States and its Allies and partners struggle to survive in this new world order. New technologies, alliances, and potential adversaries' willingness to do what the West will not has demonstrated core vulnerabilities in global democracies.

THE JOINT FUNCTIONS

FIRES

The combination of technological breakthroughs (e.g., **directed energy weapons, unmanned aerial vehicles, long term/low-orbit surveillance systems**, **expanded nuclear arsenals**, **hypersonics**) and rapid proliferation of advanced technologies lead to the development of more robust **A2/AD networks.** Additionally, the proliferation of A2/AD capabilities has greatly increased deterrence from direct military territorial disputes where defense maintains a definitive advantage. For example, in the South China Sea, China regularly closes off access to foreign shipping—including U.S. vessels—due to their defenses' insurmountable advantage. Militaries are unwilling to send manned or unmanned systems against zero time-to-flight platforms due to costs of their own exquisite platforms. Although the United States still dominates in **space**, that advantage is challenged almost daily. **Next generation anti-satellite (ASAT) weapons** have increased in speed, range, and accuracy and act as deterrence for expanded usages of the domain.

Although the United States pivoted to exquisite weapons systems, its declining economy makes it difficult, if not impossible, to keep up with Chinese and Russian advances in hypersonic weapons, sixth generation planes, radar systems, and other military innovations.

PROTECTION

A zero-growth force compelled the United States military to explore more efficient and sustainable base operating and support technologies. Heavier reliance on **Allies and partners** to meet common national security objectives and maintain international order became paramount, even as alliances degraded. Fortunately, technological advancements in **wide area surveillance, detection**, and response capabilities using **human-machine teaming** of **autonomous sensor platforms** and new weapon systems fielded in the mid-2020s maximized available security force elements. The technology allowed for rapid and precise detection and engagement capabilities to interdict threats within the base security zone in light of personnel challenges.

Key Allies and partners—particularly in South and South East Asia—procured compatible air defense systems, fifth and sixth generation aircraft, **autonomous platforms**, and **common aerospace ground equipment** (AGE) that expanded combined force capability and capacity at operating locations across the Pacific. This effort maximized **interoperability** as well as **shared protection and sustainment efforts** at key regional nodes.

Force Protection Fusion Cells in the Homeland have brought together federal and local agencies to synchronize protection efforts against **transnational criminal organizations** and others operating in the gray-zone**.** The cells protect major communication and sustainment lines and critical resources like fuel and parts. Similar combined efforts are implemented abroad.

The limits on operations due to advanced **A2/AD** and **staffing shortages** forced the U.S. military to adapt to a world where Allies and partners—both inside and outside the United States—have become essential to maintain operations, even while politicians from both parties move toward isolationism. The cultural shift in a military used to self-sufficient planning has been difficult, but the benefits of coordinated efforts is infusing the U.S. military with new ideas and a better understanding of how to operate seamlessly across organizations in order to ensure all critical systems and resources are properly protected.

MOVEMENT AND MANEUVER

A2/AD networks have greatly restricted Movement and Maneuver. Low risk tolerances create strict geographical limits on military operations around the globe. New concepts of what it means to move and maneuver emerge, which increase focus on operations in domains that have less vulnerability to kinetic technological breakthroughs. Unfortunately, due to inadequate investments in cyber, the USAF has lost the ability to compete effectively in the domain, limiting its ability to use these tools to maneuver the force to a position of advantage. Contracted support and **joint government-private ventures** have made some gains in cyberspace, but have been generally slow to act and late to need.

The world is balkanized into areas of control. Militaries race to expand their bubble of control up to the adversaries' edge. Maneuvering forces into adversaries' bubbles becomes highly reliant on attritable and autonomous systems operating *en masse* in order to reduce offensive casualties and force the adversary to expend munitions. Regions without effective A2/AD proliferation systems become highly desirable locales, particularly if they possess key natural resources or harbor other geostrategic benefits; Great powers compete through all instruments of their national power to gain access and secure territories prior to their competitors, altering the geographic-based security arrangement and increasing the division between the Sino-Russia confederation and the West. Many societies see great power competition as little more than modern neo-colonialism, which leads to increased insurgencies and instability in geostrategic areas.

INFORMATION AND INTELLIGENCE

A variety of nefarious actors and entities—some backed by states—seek to collect and analyze an individual's digital tracks in order to alter micro and macro societal behaviors for their own ends. Full digital dossiers compiled over the past 40 years through licit and illicit means now give those seeking to manipulate individuals near perfect data. Nefarious actors use myriad digital means to gain control of individuals, but the primary focus is on altering people's information space and their cognitive functions.

Described in the press as "**mind control,**" these broad-based and novel forms of **individually targeted manipulation** are pernicious and widespread, creating effects on national and global levels. The information aspects of the campaigns use **a mixture of truth and MDM information** directly tied to social media and digital environment feedback from the user to generate and gain deeper and tighter control.

The IC's focus has shifted back toward more **analogue techniques** for collecting intelligence, which are historically reliable and generate higher levels of trust in resulting intelligence products. Older methods are slow in production when compared to the ability to analyze information using available **AI/ML** algorithms. A renewed reliance on human analysts makes intelligence analysis both less prolific and prone to human bias.

COMMAND AND CONTROL (C2)

Both the China's People's Liberation Army (PLA) and the U.S. military retained long-established **hierarchical systems of C2**. Unfortunately, the U.S. military agile C2 transformation program languished due to **high levels of specialization** of service-specific systems. A smaller force is now required to transact and de-conflict the increased complexity while maintaining relatively **stove-piped domain effects**. The PRC retained a strict system of hierarchical C2 by design.

Intensifying **climate change**-related natural disasters led to the **physical environment undermining C2** agility. For example, militaries were forced to focus most capacity on enduring domestic disaster relief operations. The disaster relief operations perpetuated a seemingly endless postponement of transformational C2 technology development.

Western military space, cyber, and electromagnetic domains were constantly contested with **AI-generated attacks**. Western militaries scrambled and reactively focused on pre-conflict solutions instead of resilience. With ever **increasing information barriers, low-to-no information veracity** and **degraded information storage,** the United States and mission partners resorted to utilizing traditional communication mediums, operating in severely degraded C2 states. Western society increasingly turned its back on non-essential online services due to a combination of lack of trust and service failures.

SUSTAINMENT

New means to compartmentalize key data while increasing overall information sharing has enabled interoperability. External factors limiting other aspects of the Joint Functions has increased the requirement for combined forces, which help mitigate ABO permission gaps and the increased cost of forward deployment sustainment. Remote sustainment became more difficult due to the **Sino-Russian** and proxy cooperation as well as **advanced A2/AD and failures to invest in improved energy generation in the field**.

Instead of predictive analytics enabling local **push-style logistics**, DoD agencies rely on a **pull system** that is inventory driven and flows through a long supply chain with slow processing hubs. Slower supply chains with long logistics tails limit staging options for selecting force positions. Remote, hard to reach locations become difficult to operate in and plan for, even if they offer an advantage over the adversary.

COLLAPSE

THE GLOBAL ENVIRONMENT

Great power competition over the last 20 years between China and the United States garnered impressive technological advancements in warfighting. Fortunately, the two powers refrained from meeting each other in open conflict. This was not from their lack of achieved capabilities, but rather, due to the proliferation of technological advancements across state and non-state actors. Technology advances included **quantum computing**, **autonomy**, **AI/ML,** and **directed energy**. The technological convergence has transformed warfighting while simultaneously collapsing the **world order** established in the mid-20th century. Simultaneously, disruption of long-stable systems—most notably in life sciences and socio-economics—led to effects that cascaded across disciplines and sparked innovations.

The continued incremental rise in oceanic temperatures continue to have widespread impact on **weather patterns**. By 2040, large storms, heat waves, and drought occur frequently resulting in devastating effects. Giant weather systems regularly produce hurricane-force winds and floodwaters that require vulnerable **military installations to repeatedly evacuate or disperse**. More worryingly, insurers and governments worldwide are unable to provide adequate relief, which coupled with climate-related food shortages, has led to the largest civil **migration** since the 1947 partition of India. The global movement of civilian workers undermines workforce readiness, supply chains, and destabilizes many developing world economies and governments.

In space, the commercial satellite arrays grew exponentially in the 2020s and 30s, but the systems required to track and maintain satellites remained terrestrial. The massive storm systems, global abandonment or disruption of ground facilities (both military and commercial), and spotty communications led to a commercial satellite array redirecting off-course and colliding with key **LEO communications equipment**. A chain of destruction continues as "clouds" of debris engulf the earth, significantly degrading C2 capabilities at LEO and medium-earth orbit (MEO). Entry into space is deemed too risky due to the inability to track the location of the extensive debris.

Global **A2/AD** proliferation means the Homeland is secure from large-scale, kinetic attacks from strategic great powers. However, there are still ways for **VEOs, transnational criminal organizations (TCOs),** and **emerging competition blocs** to further degrade an already stressed U.S. military. These new and expanded competition blocs have led to increased vulnerabilities to systems, materiel, and force health through attacks on vulnerable supply chains. Technology growth has confirmed an old unspoken rule: great leaps provide exponentially greater benefit to the underdogs, in relation to those who currently maintain the power structure. Smaller states, regimes, and individual actors have benefited, while those who drove the race towards new technologies ultimately undermined their own security.

The democratization of **quantum computing** and its proliferation in countries around the globe now allows anyone to purchase server time. Accordingly, any individual hacker can possess the "keys to the kingdom" to single-handedly hold any range of governments or resources in peril. The new age has realized the **dispersal of power** away from governments and to the individual. A new era of technology-enabled terrorism has begun.

Nefarious actors have attacked funding streams, power grids, and information systems (at all levels of classification and protection) in order to further disrupt government's ability to maintain order, forcing populations to turn to the new power brokers. Quantum computing had already allowed major potential

adversaries to compromise classified information systems and decrypt all previously collected information. Corporations are being continually held ransom for access to their own funding streams or logistic networks. The war of the future is centered on economic targets, fought primarily in cyberspace, and enabled by non-kinetic fires wielded by a wide range of actors.

The United States continues to internally fracture along cultural and political lines and, along with other prior **great powers,** is now on a mirrored downslide due to domestic infighting stemming from economic policy choices and distributive inequities. Smaller states try to pool their resources together to make a sprint for power. In the early 2030s, in an aim to conserve strength, the United States **stepped back significantly from the NATO security alliance** as it deemed that Russia after the Ukraine conflict was greatly weakened. Increased nationalism in Europe and the United States independently increased their internal divides, also undermining NATO. The current message from U.S. leadership is that it must protect what it has at all costs and find new ways to reverse the current trends.

Global fracturing in the means of transmission (*e.g.*, financial systems, supply chains, energy networks) has led to constant difficulties and disturbances in obtaining essential resources. Humanitarian assistance needs have surged, with worldwide requests for NGOs to invest in **food security** and **infrastructure in the developing world**. USAF Humanitarian Assistance and Disaster Response (HA/DR) demands around the world increased the operations tempo for strategic and tactical airlift assets, at significant fiscal, manpower, and equipment costs. Pressure to support other states led to U.S. partisan divides and contrarian political movements espousing an **isolationist** posture. An already **vulnerable trust** in government has ebbed further along with a compromised sense of security. Distrust is exacerbated through emergency provisions. For example, the stressed, aging infrastructure of bases required Civil Engineers increase **partnerships with local utilities** for power, water, and access to communications networks.

With an economic downturn and a reduced public interest in global security issues, the **footprint** of the USAF has shrunk significantly. Years of political polarization led to prolonged periods of continuing resolutions, freezing the **defense budget**. Assessing that the U.S. military would not be able to adequately intervene, global powers took actions felt to be in their national interest and in defiance of the **rules-based world order**.

The need for liquid fuels and predicted shortages has led to **hoarding of oil and natural gas** by many countries to meet their heating and transportation needs. Fossil fuels became less available on the markets as stocks and reserves accumulated. Additionally, the international public sentiment against Russia, as well as similar authoritarian governments, led many in the West to push for **greener energy technologies** that would shift reliance away from fossil fuels. Major oil and gas companies saw the potential for long-term profits and stepped into the renewable energy space. Adoption of nuclear energy also increased, especially throughout South and East Asia. Transportation companies announced that they would shift away from internal combustion engines to **battery powered** modes of transport while others focused resources on hydrogen and other **renewable energy sources**. The result has been an energy transportation revolution. DOD bureaucracy has led to **underinvestment of future platforms** that are not reliant on fossil fuels.

Sensor ubiquity has expanded beyond expected projections and can now provide near complete pattern-of-life information on anyone in an urban environment around the globe. Some sensors have become critical to increasing the quality of human life, especially those tracking body functions and movement, food and water stocks and distribution, and safety. Sensor data and indications, paired with developing **AI/ML modeling**, produced detailed evidence of the dire straits of resources. This drove increased turmoil in global markets as large corporations with insights into that data manipulated cost and prioritization for their gain and survival.

Organizations who harvest open-source data are bending information for their benefit. The world of **fakes (deep and cheap)** and **MDM information** has collided with **AI/ML**-enabled expansive **botnets.** Due to deep manipulation of **biometric data** and **pattern-of-life information**—botnets can now impersonate real people, constantly besting the algorithms designed to catch fakes. Those who have access to **sensor information** and the **botnets to reshape events and their perception** can now create realities for later consumers of information.

Barriers to communications have greatly increased due to disrupted and degraded systems coupled with invalid and false MDM information. PNT systems critical to global commerce and modern military C2 have been gravely disrupted. States are becoming increasingly insular and antiquated methods of communication see a resurgence. Accordingly, less interconnectedness with other states at a time of massive human migration perpetuates changes to the world order, which is increasingly **fragmented** and **nationalistic**. **Supply chains** are reevaluated and shortened whenever possible. Each country becomes more focused on ways to harness resources and develop new means to provide sustenance to the population with dwindling natural resources as the physical environment becomes more hostile. In sum, states seek to become islands unto themselves.

THE JOINT FUNCTIONS

FIRES

Holding a target at risk does not require building mass kinetic fires and large financial resources. Technology has enabled the shift to a **non-kinetic strike arena**. Through the predominate use of the **cyber** and **electromagnetic spectrum operations**, actors can strike at will from around the world while remaining in the shadows. These technologies, coupled with constrains and vulnerabilities of legacy refueling assets, has degraded the range of conventional platform operability.

The results of a long great power struggle between China and the United States have left **stockpiles of kinetic weapons** ranging from **hypersonic** missiles to **nuclear and biological weapons** with little adequate protection. Global instability and collapsing security arrangements have increased the potential use of weapons of mass destruction.

PROTECTION

The military retains robust offensive and defensive cybersecurity. **Civil security**, however, is fragile. Power grids, petroleum pipelines, and communications systems are subject to frequent **gray-zone attacks**. Most of these attacks are not crippling, but are significant enough to cause network outages at military installations. Some fear that properly timed outages could delay critical missions. More concerning are vulnerabilities created in resource supplies such as **food and water**. Most installations are reliant on civil utilities and cannot protect the facilities from either malicious cyber activity or other efforts against civilian targets. Disruptions in shipping have led to attempts at food contamination as well as mild food borne illness outbreaks at installations due to spoilage and improper storage during transport.

MOVEMENT AND MANEUVER

The DOD has been unable to keep pace with the **commercial transportation developments** in green energy. Reliance on cost-prohibitive and obsolete combustible fuels have hampered operations. Combustible fuel is in limited supply relative to its need for fuel-inefficient platforms that the USAF still operates. Mobility platforms are available, but overtasked. Fighters are limited in their ability to **mass forces** to provide strike capability. Long-range strike platforms are largely unable to fly in numbers needed to provide the required effects. This constraint leads to an inability to mobilize a force with necessary **speed,** making the USAF too limited to respond effectively to conflict.

The USAF is unable to adopt fuel efficient platforms and rapidly move forces or provide strike. **ABO** is either not available or highly caveated. The shift in priorities from security to **humanitarian efforts** has displaced desire for military presence in most of the world. The availability of basing in partner states was seen by many countries as the means for great powers to launch invasion forces and entangle host-countries in conflicts.

Changing worldwide attitudes toward the role of the military resulted in almost no meaningful ability to move and maneuver the force globally. The result is a total collapse in the ability of the USAF to respond in the event of a global crisis. The nation's leaders did not take advantage of opportunities to modernize and adapt to long-term technological and social changes whose signs were evident decades prior.

INFORMATION AND INTELLIGENCE

Original sensor content is scooped up as fast as it is produced, redirected, altered, shaped, or removed to the desires of those MDM informers and then released to proliferate in the information environment. The information is molded to address large audiences and set deep frames (just as propaganda had done for centuries)—but is also micro-targeted and adjusted to individuals based on their sensor data in order to achieve the results of the adaptive botnet owners. Instantaneous bio-feedback networks allow those with ulterior motives to shape citizens' perceptions and ideas. The question becomes who can shape information with greater speed and effect in order to achieve their ends. Unfortunately, U.S. competitors currently hold the advantage of speed in the battlespace. The world of information is one big spoof designed to serve specific powers with the ability to control it.

The IC struggles in the new environment and long-reliable methods of operating must be dropped in favor of finding truth in the emergent information chaos. **Stovepipes in collections** have increased in order to safeguard data and to ensure taskings narrow enough to be accomplished in the MDM information space. Potential adversaries continually shutdown transmission networks and undermine the ability to transfer trustworthy information into the space—overwriting it almost instantaneously with false narratives. For intelligence, the only way to find out what is actually happening is to unplug and go back to **analog methods** since there is ubiquitous data poisoning in sensor systems. A greater reliance on human methods and sources becomes paramount as first hand observations—while skewed by their the observers' **personalized information space**—still hold more merit than any attempt to collect from digital means. The speed of MDM information provides little succor for intelligence because the utility of "truth" disappears when the entire landscape is a bot-enabled neo-truth.

In the battlespace, where facts matter, intelligence is often too little too late. Competitor automated-shaping operations of information flows means the content cannot be trusted; accordingly, risk increases while the public and policy makers' tolerance for risk and uncertainty decreases due to their belief in the strength of the sensor-connected world. Commanders no longer fear the fog of war; instead, they fear the

ultimate deception of a hall of mirrors where only illusions of actual information exists in all domains of the fight and across all aspects of policy, economics, society, and cognition.

COMMAND AND CONTROL (C2)

From the C2 perspective, inclement weather diminishes satellite communication, knocks out cell towers and communication nodes, and generally disrupts physical (and electromagnetic) information flows. Communications consistently fail or are disrupted, causing significant degradation to C2.

Potential adversary campaigns seek to disrupt trust in key leaders in the command structure and increase disobedience in the ranks, which leads to decreases in workflow and low morale. The pushback against top-down leadership coupled with the inability to effectively communicate leads to a disaggregation of power to those whose systems are still networked together. This cell-based, **decentralized structure** requires high-level mission-type orders (MTOs) and capable forces at all levels able to carry out the Commander's intent, pushing up information when possible and generally given wider discretion to get the job done. The dysfunctional C2 and new methods of command slow all aspects of operations and make states highly risk averse to pursuing large military campaigns for fear of execution failures.

Due to resource shortages, military C2 leaders are tasked with establishing a ration system (one it uses internally to entice members possessing essential skillsets and valuable knowledge to join). Military control in many states has become second-nature due to prolonged states of emergency. For much of the world, the values of survival outweigh the desire for freedom.

SUSTAINMENT

Shortages of high demand, exquisite commodities persist and many natural resources are not available in local markets. A fractured system has led to massive supply chain disruptions and other critical sustainment shortfalls across the globe. As consequence to the supply chain breakdowns, failures in automated maintenance and repair systems are preventing simple maintenance functions. The USAF returns to manual processes in an attempt to reinforce underlying supply and sustainment infrastructure, further slowing supply chain deliveries and leading to massive inefficiencies in logistics.

To fill subsequent sustainment gaps, the government has used the military to provide support to civil authorities with sustainment shortfalls and to secure supply networks. The corresponding increase in responsibility has led the DOD to shift the military's focus to domestic stabilization and the safe delivery of critical supplies across the nation, hampering the ability to adequately defend the Homeland from external threats. At this point, the United States is considering nationalizing key logistics companies to overcome key supply chain breakdowns and bring critical skill to overcome nationwide supply chain failures.

CONCLUSION

The scenarios in the report are meant to challenge conceptions. Readers should maintain healthy skepticism about each trend's direction and velocity while carefully considering externalities and multi-ordered effect cascades that may occur from decisions they make today. None of the trends are inevitable and few will occur in the manner laid out in this report. The goal of this report is to expand thinking and ensure that the organization does not commit the analytic mistakes of groupthink and singular visions of what is possible. This report succeeds if it provokes readers to think about the future in a new way and opens the aperture on what they believe may be possible.

This report is a diagnostic tool, and therefore does not provide recommendations. However, the course of building this report generated broad takeaways exist that it would be remiss not to share.

TAKEAWAYS

- **Transformational Computing**. AI/ML, automation, autonomous systems, and quantum have the potential to rewrite the world over the next twenty years. These trends consistently emerged in each of the joint functions and scenarios. The competition for next generation computing capabilities could have significant consequences on the global balance of power.

- **The Myth of Sanctuary**. Without effective countermeasures, advances in sensors and connected weapons systems have the power to render concepts of sanctuary a myth. It will be possible to create destructive effects at scale while remaining anonymous. This makes protecting the United States homeland much more difficult.

- **Cognitive Soft Targets**. Advances in AI/ML, neuroscience, and informational operations will lead to an expanded attack surface within the cognitive dimension. It will be possible to both perceive the world more accurately and be deceived in subtle but devastating ways. The ability to understand the world and create correct decisions faster while inhibiting an adversary's decision cycle is a key to strategic superiority, and strong countries devote large amounts of resources to this effort.

- **Force Multipliers**. Surprise developments act as force multipliers; breakthroughs in these trends—which are often technological—will create effect cascades across other trend categories. Examples in the report include, but are not limited to: AI/ML, Quantum Computing, Directed Energy, Energy Webs, Sensor Ubiquity, and Space Operations.

- **Economic Interconnectedness.** Globalization increases economic and soft power opportunities while also increasing attack surfaces and exploitable vulnerabilities. At the same time, deglobalization fractures trading and intellectual collaboration. The balance of geostrategic interconnectedness coupled with disparate blocs defines the next 20 years.

- **Life Science Collapse**. Future capabilities in commercial and defense sectors can allow actors to purposefully or inadvertently terminate the essentials of life. Biological functions require key resources, many of which are scarce and becoming scarer. Our military will be asked to support contingencies while also being affected by disruptions in biology.

APPENDIX A: KEY TRENDS

Emerging Trends and Structural Forces found to have key impacts in the scenario are listed below. They are sorted into their categories using the scanning framework PESTL+MC (Policy, Economic, Social, Technology, Life Sciences, Military, and Cognition). Other PESTL+MC categories that the trend cross-cuts are listed in brackets. A brief open-source and non-doctrinal description of each major trend follows. A simplified impact rating is also listed and stems from a post-scenario analysis. The rating provides an additional layer of high-medium-low impact based upon potential time horizons, an estimate of plausibility, and severity of impact. The trends below do not account for all of the trends in this report and do not account for whether a trend's potential impact is beneficial or harmful to the USAF.

POLICY

- **Allies and Partner Interdependencies** (*Policy, Military, Economic, Technology, Cognition, Social*); *Scenario Impact Level: High*
  Allies and partners have played critical roles in the U.S. defense structure since its inception. Simply put, they are force multipliers that expand U.S. power, legitimacy, influence, and geographic reach. Allies and partners bring unique perspectives, tailored capabilities and forces, and access to critical regions that complement U.S. assets. Interdependence allows both entities to share a wide range of mutual security and economic interests underpinned by shared values, military interoperability, and strong defense industrial partnerships.

- **Defense Budget Prioritization** (*Policy*, *Military*, *Economics, Cognition*); *Scenario Impact Level: High*
  Defense Budget Prioritization refers to money allocated for either the acquisition of goods or the provision of services. Investments in emerging technologies and platforms for the future fight must be balanced with the need to counter threats. As DOD leadership changes and shapes a new strategy, its priorities in the defense budget could change as well. Militaries can be constrained by budgetary pressures with programs and investments being diverted to other interests.

- **Great Power Competition** (*Policy, Economic, Social, Military, Cognition*); *Scenario Impact Level: Medium*
  Great Power Competition is a theory for viewing international relations. Under the framework, Great Power Competition occurs when large states (or coalitions of states) vie for power (Diplomatic, Information, Military, and Economic) on a global scale. Global power projection continues into the competition phase so long as no party becomes a hegemon and the situation does not devolve to either prolonged crisis or conflict. Great Power Competition is one of the great shapers of history. Under the framework, the United States views China's current rise and Russia's continued expansionist ambitions as a threat to its own power (and vice-versa). States and coalitions of states will therefore act to limit the power of others while seeking to strengthen seeking to their own positions in comparison to others.

ECONOMIC

- **Energy Costs** (*Economic, Technology, Social, Life Sciences, Military); Scenario Impact Level: Medium*

The cost of energy is a critical and fundamental building block to the advancement of civilization and its technologies. Lower-cost energy creates savings and efficiencies that drive economic growth and innovation, which accelerate modernization. High costs for energy inhibit production and slow progress. Novel breakthroughs in energy storage and generation can have compounding effects across other trends lines. Likewise, physical limits on the storage of energy constrains available opportunities; an example is the energy capacity of fossil fuels, which impacts transportation options. New means to create, store, and move energy to the point of use can affect cost and societal energy consumption.

- **Human Capital** (*Economic, Social, Military*); *Scenario Impact Level: High*
  Human capital is the people in an organization coupled with their knowledge, skills, and abilities. Good human capital choices create competitive advantage and provide stable and sustainable, long-term growth to an organization. Military human capital investments range across a wide scope of functional area and career fields. New methods, technologies, and concepts for optimizing performance and increasing force readiness have the potential to greatly impact any future fight.

- **Resource Access and Scarcity** (*Economic, Military, Social, Life Sciences, Policy*); *Scenario Impact Level: High*
  Resource scarcity is the economic theory that as required resources become rarer, the price increases as does the willingness for conflict over those scarce resources. This occurs when societies harvest finite resources or when they remove renewable resources faster than their replenishment rate. Drivers include overconsumption, overpopulation, and new technological requirements to adapt from other limited resources (*e.g.*, battery components replacing oil). Many resources critical to sustaining life—(*e.g.*, food, water, shelter)—and our way of life (*e.g.*, energy, elements for medicine and medical devices) are in jeopardy of causing shortages if the use of such resources outstrips technological and social abilities to adapt.

- **Supply Chains** (*Economic, Military, Policy*); *Scenario Impact Level: High*
  Supply chain management focuses on the risk to goods coming from suppliers and vendors through the entire process including needs for required materials, manufacture, logistics, transportation, and delivery. Its goal is to identify, analyze, and mitigate the risks inherent in working with other organizations as part of a supply chain. The supply chain issues and risks will be mitigated against threats including purposeful or incidental disruption and degradation.

SOCIAL

- **Degradation of State and National Boundaries** (*Social, Life Sciences, Economic, Cognition*); *Scenario Impact Score: Low*
  Degraded state boundaries refers to the erosion of borders that outline the territory of a country. While national boundaries are fundamentally a political denomination, they can be defined by geographical barriers, cultural differences, or political decisions. This degradation is due to increased global instability, weakened states, diffusion of power, and interconnectedness.

- **Demographics** (*Social, Economic, Policy, Military, Cognition*); Scenario Impact level: *Medium*
  Demographics refers to the statistical data relating to the population, such as age or income, as well as particular groups within it. The impact of demographics can be both direct and indirect. One direct impact is that larger states will have proportionally more members of the population available for military service; another impact is that aged-based population bubbles may hit critical career points at the same time (e.g., retirement) and create anomalous events in the social system. Indirect impacts

of demographics can affect key organizational drivers such as economic growth. Changes in demographics can shape many policies, social issues, or drive military action.

- **Mass Displacement and Migration** (*Social, Economic, Policy*); *Scenario Impact Score: High*
  Mass Displacement refers to large scale removal of something from its natural environment, the unplanned relocation of people within countries and across borders. Migration is the movement of people from one place to another with the intention of temporarily or permanently settling. Displacement and migration increased due to several reasons including population growth, increasing connectivity, trade, lack of security, demographic imbalances, and climate change. These movements requires host cities and governments to consider not only the response capacity and needs of the existing population, but also that of new populations.

- **Political Polarization** (*Social, Policy, Cognition*); *Scenario Impact Score: High*
  Political polarization occurs when subsets of a population adopt increasingly dissimilar attitudes toward parties and party members as well as ideologies and policies. The polarizing pressures of partisan media, social media, and even deeply rooted cultural, historical, and regional divides cause political polarization in different populations around the globe. Under strong polarization, the gap between the policy and political party members' positions grows and more citizens identify consistently with the main policy positions of their party and shed non-aligned viewpoints.

- **Power Diffusion** (*Social, Economic, Technology, Cognition*); *Scenario Impact Score: Medium*
  Power diffusion is the movement of power into networks and away from hierarchical structures is often cyclical. The power diffusion is a reaction to perceived unjust and unresponsive power and wealth concentrations. The movement relies on new ideas of how to improve and disrupt current society coupled with technologies for spreading and shaping those ideas. When networked power is too diffuse, unstable, and inefficient, centralized and hierarchal power accumulation may result.

TECHNOLOGY

- **Additive Manufacturing** (*Military, Economic*); Scenario Impact Score: *Medium*
  Also known as 3D printing, additive manufacturing allows researchers to create physical, three-dimensional objects directly from a computer design file. The process bears similarity to using common desktop printers to form images—but instead of ink, 3D printers use a wide variety of materials ranging from polymer composites, metals and ceramics to food, foams, gels, and even living tissue. Additive manufacturing has potential to reduce energy use and can cut waste and materials costs compared to traditional manufacturing methods. Additionally, this method also has the potential to improve energy productivity, allow for greater design flexibility and reduce production time.

- **Artificial Intelligence/Machine Learning (AI/ML)** (*Technology, Cognition, Social, Military*); *Scenario Impact Level: High*
  Artificial Intelligence/Machine Learning is the ability of machines to perform tasks that normally require human intelligence. Machine Learning is a subset of AI that allows machines to acquire "knowledge" through data analysis. Both rely on massive sets of data for analysis and development of algorithms. Current narrow AI/ML focused on solving one problem well; General AI—which does not currently exist—would be applicable in any domain to solve a multitude of problems. When mature, AI/ML will allow previously expensive and complex tasks to be performed by machines to aid or replace decision making traditionally done by humans.

- **Autonomous Systems** (*Technology, Military*); *Scenario Impact Level: Medium*
  An autonomous system is one that can achieve a given set of goals in a changing environment without human control or intervention through the ability to sense information about its surroundings. Autonomous vehicles allow the ability to employ an asset on a mission without putting a human operator at risk and without need for an operator input if conditions of the mission change. Advances in technology have increased the production of autonomous systems including vehicles, robots, autonomous warehouse and factory systems and drones.

- **Directed Energy** (*Technology, Military*); *Scenario Impact Level: Medium*
  Directed-energy weapons emit energy in an aimed direction without the means of a projectile. It transfers energy to a target for a desired effect. Intended effects on humans may be non-lethal or lethal. The creating and testing of directed-energy weapons have increased due to advances in research. These weapons possess the ability to strike without actionable warning making defense against directed energy weapons extremely difficult.

- **Information Warfare** (*Military, Policy*); Scenario Impact Score: *High*
  Information Warfare (IW) is defined as the employment of military capabilities in and through the Information Environment to deliberately affect adversary human and system behavior and to preserve friendly freedom of action during cooperation, competition, and conflict. It consists of controlling one's own information space, protecting access to one's own information, while acquiring and using the opponent's information, destroying their information systems and disrupting the information flow. Gaining information or access to systems as a means of cyber offense or defense. IW can be used as an offensive or defensive tool.

- **Low Earth Orbit (LEO) Capabilities** (*Military, Economic*); Scenario Impact Score: *High*
  Low Earth orbit (LEO) is an altitude that lies towards the lower end of the range of possible orbits. Recent, rapid technology advancements in the commercial sector has enabled the capability of using hundreds of small satellites spread out across that orbit to perform communications, missile warning, and various other military missions.

- **Metaverses** (*Technology, Social, Cognition, Economic, Military*); *Scenario Impact Score: Medium*
  Metaverses generally refers to the concept of a highly immersive virtual worlds where people gather to socialize, play, and work. Metaverses will radically increase the affordability of a wide range of experiences and products. It will also introduce new possibilities that don't currently exist at all, even for the ultra-wealthy. Behavior in Metaverses could have real-world consequences like the current challenges society faces with social media and video games. Some common cyber-criminal offenses that may become associated with any digital enterprise include fraud, money laundering, child exploitation, and other malicious cyber activity.

- **Quantum** (Operationalize) (*Military, Social*); Scenario Impact Score: *High*
  The idea of utilizing quantum mechanics to process information for computation and communication, sensing, biology, and chemistry. Research, Development, Test, and Evaluation (RDT&E) in this area is relatively nascent, but many novel applications are emerging. Despite the implications quantum technologies pose, there is a relatively small pool of specialists in the field, especially in the military. As with artificial intelligence, falling behind peers or near-peers in the field of quantum information sciences could be catastrophic.

- **Universal Federated Sensing Web** (*Technology, Social, Military*); Scenario Impact Score: *High*
  Federated sensing has emerged as a distributed and collaborative AI/ML approach to receiving

detailed information about the environment. This data can enable a multitude of intelligent Internet of Things (IoT) applications by allowing for AI training at distributed IoT devices without the need for data sharing. The latest advancements in wireless communication technology have propelled the widespread use of smart technologies, cloud computing, and the IoT.

- **Ubiquitous Sensors** (*Social)*; Scenario Impact Score: *High*
  A ubiquitous sensor network (USN) is one that connects all possible sensors in a given network or environment which, theoretically, could be global. Typically, the sensors in a USN are smart sensors, which take input from the physical environment and use built-in compute resources to perform predefined functions upon detection of specific input, and then process data before passing it on. Ubiquitous sensor networks can yield significant amounts of data when systems and software are available to make sense of the data collected and drive action. This can be augmented though AI/ML algorithms to prompt or automate actions within the network.

LIFE SCIENCES

- **Bio-Engineered Attack** (*Military, Life Science*); Scenario Impact Level: *High*
  A bio-engineered attack is the intentional release of a genetically modified pathogen (disease causing agent) or biotoxin (poisonous substance produced by a living organism) against humans, plants, or animals. Modification could increase parameters such as survivability, infectivity, virulence, and/or drug resistance. An attack against people could be used to cause illness, death, fear, societal disruption, and economic damage. Biological weapons have evolved with advancing technologies.

- **Biological Info Storage and Processing** (*Technology, Social*); Scenario Impact Level: *Medium*
  Referred to as the "DNA-of-Things" (DoT), this rapidly growing field of technology uses sequences of DNA to store data. DNA has a potential storage density orders of magnitude larger than current mainstream storage mediums allowing for significant storage for a relatively small size.

- **Climate Change** (*Social, Economic*); Scenario Impact Level: *Medium*
  Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural through variations in the solar cycle or influenced by human activity. Human activities have been the main driver of climate change since the late 19th century, primarily due to burning fossil fuels like coal, oil, and gas. Climate change can affect health, ability to grow food, housing, safety and work. Conditions like sea-level rise and saltwater intrusion have advanced to the point where whole communities have had to relocate, and protracted droughts are putting people at risk of famine. In the future, the number of "climate refugees" is expected to rise.

- **Gene Editing /CRISPR** (*Life Sciences*, *Technology, Social*); *Scenario Impact Level: Medium*
  CRISPR is a technology that can be used to edit genes. Technologies are used to determine which genes express desired traits, isolate and remove desired genes, and insert that gene code into another cell or organism. Gene editing has applications in medicine, research, industry and agriculture and can be used on a wide range of plants, animals, and microorganisms.

MILITARY

- **Access, Basing, Overflight** (ABO) / Posture (*Military*); Scenario Impact Level: *Medium*

ABO is the ability to land in or establish aircraft support functions in a foreign state's territory, or fly though a foreign state's national airspace. ABO is important to establishing operations for support of Air Force Operations. Through integrated supply chains, personnel, and interoperability of systems, Allies and partners have become critical in generating power from U.S. held locations just as U.S. forces have become essential in supporting allied positions. Basing and overflight access may become unconditional as both economic and military ties are deepened. If ABO is not possible, it constrains function and may degrade mission capability.

- **Autonomous Platforms** (*Technology*); Scenario Impact Level: *Medium*
  Unmanned vehicles which are primarily self-controlled by onboard autonomy and/or artificial intelligence software systems and are designed to collaborate with other manned and unmanned platforms to achieve specific missions. To achieve true collaboration, either autonomously or on-demand, Autonomous Platforms need AI, predictive analytics, and network connectivity (global or localized depending on the situation). The end state of APs is a family of vehicles that can integrate with dynamic operations with little to no human interaction. This includes acting on mission orders to achieve a commander's intent. APs enable air operations with decreased risk to force. Additionally, wide proliferation of APs across the joint force will improve situational awareness, availability of information, and speed of decision/action.

- **Genetic Weapons** (*Technology, Life Sciences*); Scenario Impact Level: *High*
  Genetic Weapons are an evolution of biological weapons. Biological weapons are the use of microbial or other biological agents, or toxins, that have no justification for prophylactic, protective or other peaceful purposes. Biological weapons have the ability to incapacitate forces and overwhelm healthcare resources. Genetic weapons are biological weapons that are genetically engineered to target populations that have specific genetic markers. These weapons may be able to, evade treatments or persist in the environment making their use extremely difficult to counteract.

- **Long-Range Fires** (*Technology*); Scenario Impact Level: *High*
  Long-range precision fires is a priority for the Air Force when it comes to developing a modernized force capable of deterring adversaries. However, pursuit of such weapons is extremely costly and the science and technology efforts are expansive. Cost of development and production of these weapons limits number and availability of preferred munitions.

- **Long-Range A2/AD** (*Technology*); Scenario Impact Level: *Medium*
  Anti-access/area-denial (A2/AD) is an attempt to prevent forces from accessing critical locations while also denying the ability to move and maneuver. Long range A2/AD is a broad attempt to keep potential adversaries out of a region by using a suite of advanced technologies (including long-range strike capabilities), strategic positioning, and deterrence. The ability to prohibit large swaths of a domain from any adversary usage increases defensive position and forces competitors to find new ends and means to achieve goals that they had planned to achieve through access and maneuver.

- **Myth of Sanctuary** (*Policy*); Scenario Impact Level: *High*
  The myth of sanctuary is the belief that a location is not vulnerable to attack by any kinetic or non-kinetic means. The belief leads to the massing of high value assets in areas of presumed safety that are not actually protected. The risk of loss or degradation of the assets is increased due to the vulnerabilities of the location.

- **Proxy War** (*Military, Policy, Social*); Scenario Impact Level: *High*

Armed conflict between two states or non-state actors which act on the instigation or on behalf of other parties that are not directly involved in the hostilities. Entities may choose to use proxies for a variety of reasons, including fear of escalation or a direct conflict, desire to keep actions hidden from their constituents or another party (including the adversary), lack of political will, risk aversion, or an unwillingness to expend key assets in the conflict. Outsized advantages may lead some entities to take asymmetric strategies that can involve proxies; this may complicate international relations, increase difficulty in verify those committing actions, and lead to poor decision making that does not fully account for the totality of the circumstances.

- **Spaced-Based Strikes** (*Technology*); Scenario Impact Level: *Medium*
  Space-based strikes require systems and/or fires that are launched from earth orbit rather than from surface or airborne vehicles. Shorter flight time means decreased advance warning of an incoming munition. Space based strike assets increase the range power while integrated C2 allows for focused targeting.

COGNITION

- **Decision-Making Speeds** (*Technology*, *Social*); Scenario Impact Level: *Medium*
  Decision making speeds refers to the ability to make decisions quickly while maintaining a certain degree of accuracy. Systems that allow for efficiency and accuracy can increase decision speed. Risk tolerances must be a factor of the desired accuracy of the decision for the organization. The ability to process large quantity of data or limited information and make a decision quickly can mean the difference of saving lives or not.

- **Ethical Asymmetries** (*Social*); Scenario Impact Level: *Medium*
  Ethical asymmetries refer to the differences in ethical norms and permissions between two separate groups. When this occurs, one group may be accepting of an action that the other group may find unacceptable. In certain situations, the differences in norms and permissions may be used to exert advantage or exploit another party to gain a favorable position.

- **Prioritization Choices** (*Policy*); Scenario Impact Level: *Low*
  Prioritization choices are processes that assess the order of importance of a particular task, project or item to an organization. This requires evaluation about what may be valuable to the organization in order to rank the options available. Once the values are placed on tasks, projects or items, organizations will order their decisions and actions based on the value. This involves varied and situational risk tolerances that may change choices for certain paradigms.

- **Risk Tolerance** (*Policy*); Scenario Impact Level: *Low*
  Under classic economic theory, individual and groups have different levels of risk acceptance and aversion, which play into their choices and decisions. Groups that have had success in limiting losses as well as those with a good amount to lose if something does not work out will often have different levels of risk aversion and acceptance. Accordingly, disrupters and change makers to systems often have great risk tolerances and are willing to act in ways and accept risks that long-standing established order would not, leading for an asymmetry in strategy options.

KEY TRENDS BY SCENARIO

Appendix B

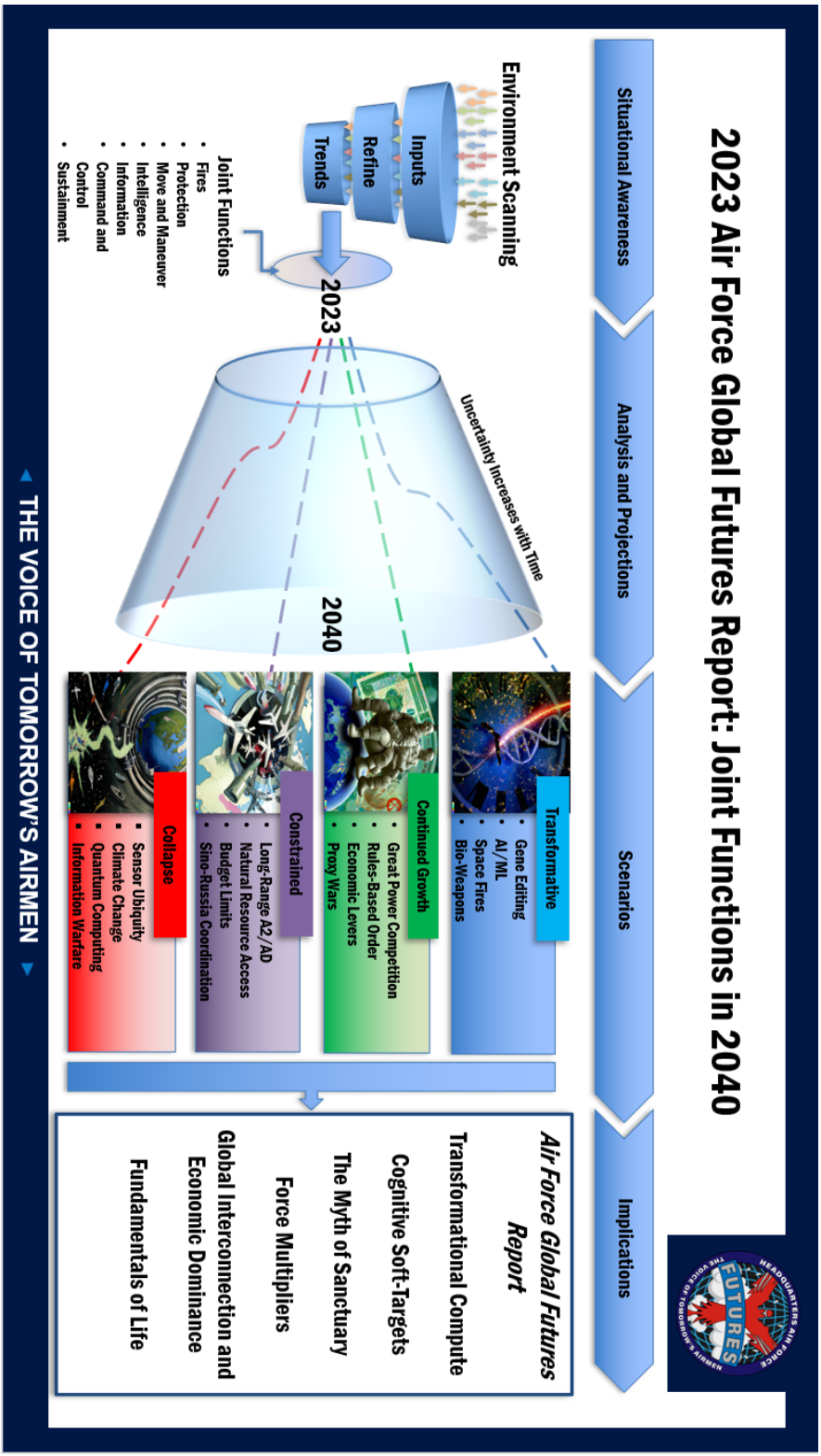
Four Archetypes

	Joint Functions: Fires	Protect	M&M	Intel & Info	C2	Sustain
Continued Growth	• Proxy Wars • AI/ML • Great Power Competition • Gene Editing (CRISPR) • Risk Tolerances	• Proxy Wars • ABO / Posture • AI/ML • Allies and Partners • Myth of Sanctuary • Supply Chains • Great Power Competition	• ABO / Posture • AI/ML • Supply Chains • Great Power Competition • Risk Tolerances	• AI/ML • Risk Tolerances	• AI/ML • Myth of Sanctuary • Supply Chains • Risk Tolerances	• AI/ML • Supply Chains
Transformational	• Space Fires • Bio-Weapons • AI/ML Decisions • Universal Federated Sensing Web • Additive Manufacturing	• Space Fires • Low-Cost Energy • Directed Energy • Bio-Weapons • AI/ML Decisions • Autonomous Systems • Universal Federated Sensing Web • Additive Manufacturing	• Low-Cost Energy • Directed Energy • AI/ML Decisions • Metaverses • Autonomous Systems • Universal Federated Sensing Web	• Bio-Weapons • AI/ML Decisions • Degraded Nat'l Boundaries • Universal Federated Sensing Web • Bio-Data Storage	• Space Fires • AI/ML Decisions • Autonomous Systems • Universal Federated Sensing Web • Additive Manufacturing • Bio-Data Storage	• Additive Manufacturing • Universal Federated Sensing Web • AI/ML Decisions • Metaverses
Constrained	• Space Capabilities • Budget Limits • Long-Range A2/AD • Bio-Weapons	• Political Polarization (Nat'l & Int'l) • Natural Resources Access • Human Capital • Space Capabilities • Budget Limits • Long-Range A2/AD • Bio-Weapons	• Natural Resources Access • Long-Range A2/AD	• Budget Limits • Info Operations	• Space Capabilities	• Budget Limits • Info Operations
Collapse	• Quantum Computing • Sensor Ubiquity • AI/ML	• Quantum Computing • AI/ML • Resource Scarcity • Climate Change • Space Access • Info Warfare	• Sensor Ubiquity • AI/ML	• Quantum Computing • Sensor Ubiquity • AI/ML • Info Warfare	• Quantum Computing • Sensor Ubiquity • AI/ML • Climate Change • Space Access	• Quantum Computing • Sensor Ubiquity • AI/ML • Resource Scarcity

This chart indicates trends that had the most significant impact within each scenario (Continued Growth, Transformational, Constrained, and Collapse) cross-referenced against the Joint Function(s) most affected. These Key Trends are defined in Appendix A.

AFGFR PROCESS OVERVIEW

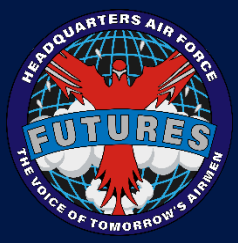
Appendix C



APPENDIX D: ACRONYM LIST

ABO	Access, Basing, and Overflight
AFGFR	Air Force Global Futures Report
AGE	Aerospace ground equipment
AI/ML	Artificial Intelligence / Machine Learning
ASAT	Anti-satellite
AOiCE	Adaptive Operations in a Contested Environment
A2/AD	Anti-Access / Area Denial
BRACs	Base realignment and closures
C2	Command and Control
COVID-19	Coronavirus disease
CRISPR	Clustered regularly interspaced short palindromic repeats
DNA	Deoxyribonucleic Acid
DOD	Department of Defense
DoT	DNA-of-Things
FOE	Future Operating Environments
GIIC	Globally Integrated Intelligence Communities
HA/DR	Humanitarian Assistance and Disaster Response
HSVTOLs	High-speed vertical takeoff and landing platforms
IC	Intelligence Community
IW	Information Warfare
LEO	Low-earth orbit
LiDAR	Light Detection and Ranging
LPI	Low Probability Intercept
MDM	Mis-,Dis-, and Mal-information
MEO	Medium-earth orbit
MIAD	Mutually instantaneous assured destruction
NATO	North Atlantic Treaty Organization
PESTL-MC	Policy, Economic, Social, Technology, Life Sciences, Military, and Cognition
PNT	Position, navigation, and timing
PRC	People's Republic of China
RDT&E	Research, Development, Test, and Evaluation
RPA	Remotely piloted aircraft
SATs	Structured Analytic Techniques
SUA	Special use airspace
TCO	Transnational criminal organizations
UAPs	Unmanned autonomous platforms

UAV	Unmanned aerial vehicle
USAF	United States Air Force
USG	United Stated Government
VEO	Violent Extremist organizations
VUCA	Volatile, Uncertain, Complex, and Ambiguous



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