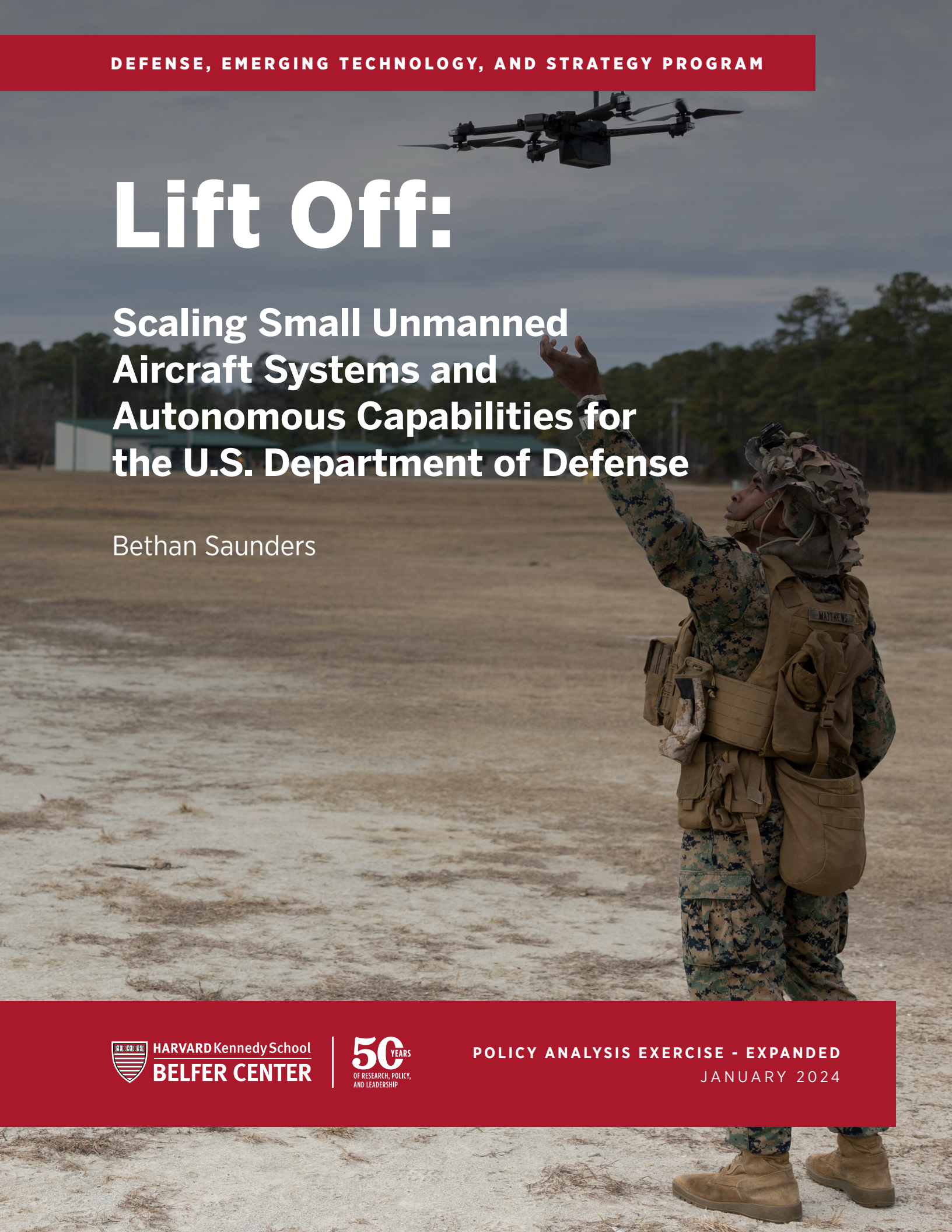
DEFENSE, EMERGING TECHNOLOGY, AND STRATEGY PROGRAM



Lift Off:

Scaling Small Unmanned Aircraft Systems and Autonomous Capabilities for the U.S. Department of Defense

Bethan Saunders

HARVARD Kennedy School
BELFER CENTER

50 YEARS
OF RESEARCH, POLICY, AND LEADERSHIP

POLICY ANALYSIS EXERCISE - EXPANDED
JANUARY 2024

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The Client Organization for this Policy Analysis Exercise by Bethan Saunders is the Office of the Undersecretary of Defense for Policy, Office of Force Development and Emerging Capabilities, at the U.S. Department of Defense.

This paper was prepared for the Harvard Kennedy School as part of MPP graduation requirements during the 2022 – 2023 academic school year. This paper reflects the views of the author and should not be viewed as representing the views of the Harvard Kennedy School, The Belfer Center, the Department of Defense, nor those of Harvard University nor any of its faculty. Any omissions, errors, or factual inaccuracies are the author's alone.

The PAE was awarded the Best PAE in Security Policy by the HKS International and Global Affairs (IGA) Area faculty.

PAE Advisors: Professor Eric Rosenbach, Professor Ash Carter

IGA Seminar Leaders: Professors Matthew Bunn and Kathryn Sikkink.

About the Defense, Emerging Technology, and Strategy Program

The Defense, Emerging Technology, and Strategy (DETS) program has a dual mission to

1. advance policy-relevant knowledge and strategy on the most important challenges at the intersection of security and emerging technology; and
2. prepare future leaders for public service in relevant arenas.

About The Author

Bethan Saunders is a Harvard Kennedy School Master in Public Policy graduate, Class of 2023. While at the Kennedy School, Bethan was a Belfer Young Leader Fellow with the Cyber Project and Technology and Public Purpose Project and the Co-Chair of the HKS student organization, Women in Defense, Development, and Diplomacy. She also worked with the Defense Innovation Unit on student research projects to accelerate commercial innovation for national security. Bethan was a Rosenthal Fellow at In-Q-Tel, focusing on national security strategy and innovation policy. Previously, Bethan was an Associate at Morgan Stanley, where she helped manage the senior-most relationships with Morgan Stanley's largest clients and covered international equity markets. She has also had internships at the White House, the U.S. State Department, and on Capitol Hill. Bethan graduated from Georgetown's School of Foreign Service.

Acknowledgments

> "In a new strategic era, and at a time of great change, the United States must continue to ensure that ours is the finest fighting force the world has ever known. To do so, we will invest and innovate...we will change how we plan, how we operate, and even how we fight. But we'll never change what we're willing to fight for: for our safety and interests, for those of our friends and allies, and for the values and principles that have benefited so many for so long."
>
> – Former Secretary of Defense Ash Carter
> *Remarks at U.S. Naval Academy Commencement on May 27, 2016*

This Policy Analysis Exercise is dedicated in honor and memory of Professor Ash Carter.

Professor Carter's Harvard Kennedy School IGA 282 Course, Spring 2022

I would like to thank the following individuals and organizations for their support throughout my research process:

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Executive Summary

In this new era of strategic competition, the Department of Defense (DoD) must rapidly scale emerging and innovative technologies to maintain U.S. global leadership. However, due to its antiquated acquisition systems, the U.S. military risks falling behind its adversaries in delivering cutting-edge and emerging capabilities to warfighters.

This challenge is especially evident for scaling autonomous technologies, which have been identified by the DoD as a critical technology area.[1] With the most advanced capabilities existing outside of traditional acquisition partners, the DoD's process for fielding and scaling new capabilities is too slow and complex to acquire essential technologies at the speed of relevance. Despite the high interest and significant efforts from across the DoD, rapid and effective scaling of many emerging autonomous technologies remains elusive.

Small Unmanned Aircraft Systems (Small UAS), a critical autonomous technology in modern warfare that has encountered significant challenges in effective scaling, are the primary focus of this report.

Problem Statement: Why Small UAS Capabilities Matter

In an era of great power competition, small UAS has become a strategic capability that fills critical joint warfighting gaps.[2] However, scaling small UAS presents a significant challenge for the DoD for two main reasons:

- The most advanced small UAS capabilities for military applications are all developed and owned by private-sector companies outside of traditional acquisition partners.
- Small UAS with advanced autonomous capabilities are heavily software-enabled hardware, which adds significant complexity for acquisition due to the DoD's outdated procurement categories and processes.

Through interviews with over 50 experts from across the defense innovation ecosystem and analyses of existing DoD small UAS scaling efforts, this report investigates how the Defense Department can overcome these challenges to more rapidly scale small UAS capabilities.

During the research and interview process, it was clear how many dedicated policymakers and experts are working on this problem. This report endeavors to bring a specific, capability-focused perspective to the ongoing discourse.

Findings: Key Challenges for Scaling Small UAS Capabilities

The DoD faces **six key challenges** in attempting to scale small UAS capabilities to the warfighter. These findings also apply to the broader defense acquisition system and efforts to scale other autonomous and emerging capabilities.

Requirements: The rigid, exhaustive specifications for technologies developed throughout the DoD budget requirements process prevent the DoD from rapidly accessing small UAS with advanced capabilities, regardless of demand from the Services or warfighters.

Culture: The DoD's acquisition officials are highly risk-averse and prioritize large programs over smaller, more innovative ones. The main barrier is organizational culture – not a lack of innovation initiatives and flexible contracting authorities within the DoD.

Metrics: Every actor in the "defense innovation ecosystem" has its own metric for success. As a result, key stakeholders are not aligned to a shared mission of rapidly pushing critical technologies through the acquisition pipeline to the warfighter. For example, PMs and PEOs often see their mission as minimizing all potential risks for any program and strictly following requirements for existing capabilities, rather than rapidly delivering emerging capabilities to warfighters.

Transitions: The DoD has well-established, albeit separate, transition pathways for software and hardware. As a highly advanced, software-enabled hardware, small UAS capabilities fall between procurement funding categories and struggle to transition from prototyping exercises into funded programs.

Budget Process: The DoD's existing budgeting process is marked by long timelines and little flexibility, which is a significant hindrance to scaling emerging capabilities like small UAS. As software-enabled hardware, small UAS capabilities are vulnerable to tight restrictions and "color of money" allocations that make it difficult for acquisition officials to find funding through traditional acquisition pathways.

Workforce: Much of the DoD acquisition workforce would benefit from additional commercial, software, and product development experience and training support. The flexible authorities for scaling small UAS capabilities exist, but acquisition officials have not received the necessary training, leadership support, and exposure to utilize these tools with confidence.

Policy Recommendations

To address these challenges, the U.S. Defense Department should:

1. **Create a small UAS portfolio or "Capability of Record":** Given the rapid speed of technological innovation, there is an urgent and well-established need to develop strategy-driven budgets and capabilities.[3] Small UAS is the ideal capability to launch the portfolio budgeting approach, given its cross-domain abilities and urgent operational needs. The ongoing war in Ukraine has demonstrated the strategic importance of small UAS capabilities and provided an important window of opportunity to advocate for a new funding model to Congress.

2. **Expand authorities and pathways to enable "autonomy as a service" contracting authority for small UAS:** The leading American small UAS companies consider themselves software companies – not hardware producers.[4] As an autonomous and software-enabled technology, small UAS software constantly evolves with new updates to expand capabilities and address software bugs. As a result, the DoD must empower the "as a service" contracting model as the most effective way to rapidly leverage the most advanced small UAS capabilities, which are all in the private sector.

3. **Strengthen the U.S. small UAS industrial base:** Meaningful scaling is not possible without a robust domestic industrial base. Warfighters need small UAS capabilities, but many of the start-ups that manufacture some of the most cutting-edge capabilities do not have the supply chain needed to scale rapidly. The DoD must better support the expansion of a domestic dual-use market for small UAS.

4. **Improve acquisition workforce development and build innovation connectivity:** To more rapidly field and scale small UAS capabilities, the DoD needs to build trust, improve information exchange, and facilitate more networks between traditional contracting officers, program managers, and defense innovation organizations. Improving transition rates for commercial capabilities like small UAS depends on connectivity between programs of record and defense innovation entities that bring in commercial capabilities.

5. **Prioritize rapid user feedback:** Facilitating live user feedback is critical for ensuring rapid scaling and avoiding drawn-out prototyping. First, it trains the end users (i.e., servicemembers) in the new capabilities and provides critical feedback and development opportunities for commercial companies. Second, it shortens the communication cycles between commercial developers and end users in the prototyping and testing phases, which helps cut down on drawn-out prototyping exercises and promotes more rapid scaling.

With these changes, the Defense Department can more effectively deliver high-impact small UAS solutions to the warfighter at the speed of relevance. DoD senior leadership must work closely with stakeholders from across the defense innovation ecosystem and in Congress to advance U.S. strategic capabilities and maintain U.S. global leadership through technological investments and acquisition reform.

I. Introduction

The United States Department of Defense's (DoD) biggest challenge isn't innovation – it's adopting and implementing innovation. The combination of legislative procedures, internal bureaucratic hurdles, and a disconnect with the U.S. innovation sector has resulted in an acquisition system that struggles to swiftly integrate and expand crucial, cutting-edge technology for military use.

The Biden Administration's National Security Strategy has described the next ten years as a "decisive decade," and the United States must maintain a credible deterrent to prevent military action by its adversaries.[5] However, China's military technology acquisition cycle is over five times faster than the U.S.'s cycle, and China spends approximately one-twentieth as much as the U.S. to acquire the same capability.[6] Additionally, the U.S. spent nearly three times as much on procurement as on research and development (R&D) in the 1980s. Today, the U.S. spends roughly equal amounts on procurement and on R&D, which indicates a major reduction in the resources allocated to acquiring military capabilities relative to the resources required to create these capabilities.[7] Although the U.S. is a global leader in developing critical emerging technologies, cutting-edge capabilities are not being rapidly or effectively fielded to the warfighter to prepare for an evolving threat landscape.

This report aims to address this strategic challenge and provide concrete recommendations for the Defense Department for scaling emerging capabilities. Within the DoD's 14 critical technology areas, this report focuses on scaling **small Unmanned Aircraft Systems (small UAS)**. This report details **six** comprehensive findings that were developed through the analysis of **55** interviews and proposes **five** concrete recommendations for more rapidly and effectively scaling small UAS and emerging autonomous capabilities for the DoD.

About the Policy Analysis Exercise

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Methodology

Expert interviews from across the national security and defense innovation ecosystems are the most significant component of this report's research methodology and design. The author conducted **55** interviews, totaling approximately over **35 hours of expert discussion**. The interviews included nuanced perspectives from a diverse set of stakeholders involved in the defense innovation ecosystem and small UAS technology scaling process. Interviews were supplemented with an analysis of case studies and primary and secondary source material. This report also includes several case studies to provide additional insight into current small UAS scaling initiatives within the DoD.

Any omissions, errors, or factual inaccuracies are the author's alone. This Policy Analysis Exercise reflects the views of the author and should not be viewed as representing the views of the Department of Defense, nor those of Harvard University nor any of its faculty.

II. Mapping the U.S. Defense Innovation Ecosystem

> "We don't seek to crush or control innovation, or make it toe the party line. Instead, our goal is to seed, spark, and stoke the flames of innovation... The DoD's past innovation pursuits often had labels specific to their times and origins: The revolution in military affairs. Transformation. Offset strategies. The defense innovation initiative. These are just some of the monikers applied to U.S. defense efforts over the decades. But no matter the name, they all shared a simple and compelling proposition: to create and exploit change as a military opportunity."
>
> – Deputy Secretary of Defense Kathleen Hicks, Keynote Address: 'The Urgency to Innovate', August 28, 2023

Introduction

In the last ten years, the Defense Department has taken considerable steps to create innovation pathways and programs to advance critical new, commercial technologies for military use. Dubbed "the defense innovation ecosystem," this vast network of initiatives both within and outside of the DoD seeks to bridge gaps between the military and commercial industries, identify and prototype emerging and frontier technologies, and spur further innovation to strengthen national security.

"Innovation" and "defense innovation" are terms used across the Defense Department, but often with many different meanings and missions. Furthermore, the rapid proliferation of organizations within the "defense innovation ecosystem" has led to a very broad and somewhat unclear understanding of the DoD's main goals, strategies, and definitions. This challenge will be discussed further in the findings. However, the goal of this section is to provide definitions and a high-level context of the current innovation environment.

For the purpose of this report, the "**defense innovation ecosystem**" refers to the DoD organizations, activities, pilot programs, functions, processes, hubs, and initiatives that aim to develop, produce, and field new or improved technologies (including purely military, dual-use, or commercial) for military use.

As stated, the goal of this report is to provide recommendations for scaling small UAS capabilities for military use. "Scaling" has varying definitions across different DoD innovation organizations and offices. In this report, **"scaling" is defined as successfully transitioning a small UAS technology to a program manager (PM), Program Executive Office (PEO), operational unit, or another funding mechanism that leads to production, fielding to the warfighter, and then continued operation and maintenance**. This definition is not perfect or all-encompassing of what scaling efforts mean for different services or defense innovation organizations, but it reflects the priority of this report to propose recommendations that close the capability gap for the warfighter.

Defense Innovation Organizations

In response to evolving global threats and the rapid pace of technological advancements, various DoD defense innovation and partner organizations have been established to strengthen the U.S. military's capabilities and readiness for future conflicts. The following charts, adapted from open source research and existing compilations, outline some of the key components of the defense innovation ecosystem to showcase the many opportunities that have been created to facilitate pathways for innovative technologies to transition into DoD capabilities. This is not a comprehensive list, but a snapshot of some of the major players in the defense innovation ecosystem.

Table 1.

DoD-Wide & Office of the Secretary of Defense	
Chief Digital and Artificial Intelligence Office	National Security Innovation Network
DARPA	Rapid Innovation Fund
Defense Digital Service	Rapid Reaction Technology Office
Defense Innovation Unit	SOCOM Acquisition Agility Office
Defense Innovation Marketplace	SOFWERX
Defense Innovation Board	Small Business Technology Transfer
DEFENSEWERX	Strategic Capabilities Office
DoD Labs	OUSD Policy Force Development & Emerging Capabilities Office
ERDCWERX	Office of Strategic Capital
Joint Rapid Acquisition Cell (JRAC)	OSD Innovation Steering Group
MGMWERX	
National Security Innovation Capital	

Table 2.

U.S. Navy	U.S. Army	U.S. Air Force/ Space Force	Non-Government/ Other
CNO Rapid Innovation Cell	Army Futures Command	AFWERX	Defense Entrepreneurs Forum
NavalX	Army Rapid Capabilities Office	Air Force Research Lab	Hacking for Defense
Marine Innovation Unit	Army Applications Lab	Air Force Rapid Capabilities Office	In-Q-Tel
Naval Research Lab	Army Research Lab	AFVentures	Silicon Valley Defense Group
Navy SBIR/STTR	Army SBIR/STTR	Allied Space Accelerator	Starburst
Task Force 59	Rapid Capabilities Office	Catalyst Accelerator	MITx
Navy Unmanned Task Force	xTechsearch	Kessel Run	NATO Defence Innovation Accelerator for the North Atlantic (DIANA)
DoD Labs	OUSD Policy Force Development & Emerging Capabilities Office	Starburst Accelerator	
ERDCWERX	Office of Strategic Capital	SpaceWERX	
Joint Rapid Acquisition Cell (JRAC)	OSD Innovation Steering Group	STRIKEWERX	
MGMWERX			
National Security Innovation Capital			

Existing Flexible Budget, Spending Authorities and Programs

As seen in the charts above, the DoD has made considerable efforts to institutionalize innovation across the Department and create an "innovation ecosystem". Congress and the DoD have also worked together to take significant steps to expand flexible acquisition authorities to address the lack of agility in the budgeting and acquisition process. The following authorities and funds are some key (non-exhaustive) examples of the efforts to provide more flexible funding to the DoD and its partners for scaling innovative and commercial technology.

Table 3.

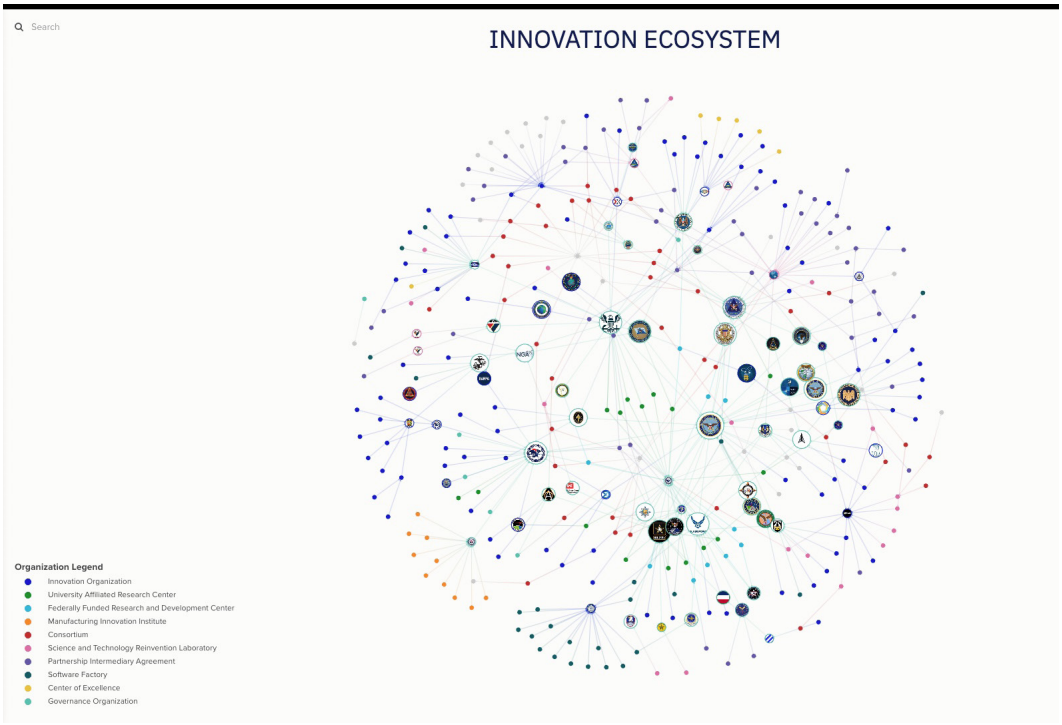
Authority/Fund	Description
Section 804 Mid-Tier Acquisition (MTAs) Pathway	Reform to create funding pathways to improve transition processes for advanced and mature prototypes. Focuses on delivering capability in a period of 2-5 years with rapid prototypes and rapid fielding with proven technology.[8]
Accelerate the Procurement and Fielding of Innovative Technologies (APFIT)	The purpose of the APFIT pilot program is to expeditiously transition technologies – with priority given to those developed by small businesses and/or nontraditional defense contractors – from pilot programs, prototype projects, and research projects into production.[9]
Other Transaction (OT) Authorities	OT authorities were created to give the DoD the flexibility necessary to adopt and incorporate business practices that reflect commercial industry standards and best practices into its award instruments. When leveraged appropriately, OTs provide access to state-of-the-art technology solutions from traditional and "Non-Traditional Defense Contractors" through a multitude of potential teaming arrangements tailored to the particular project and the needs of the participants.[10]
Rapid Innovation Fund	The Rapid Innovation Fund provides a collaborative vehicle for small businesses to provide the department with innovative technologies that can be rapidly inserted into acquisition programs that meet specific defense needs.[11]
Sec 800 Software Acquisition Authority	Directed DoD to create two software acquisition pathways: Applications and Embedded Systems. The pathway streamlines the requirements, budget, and acquisition process. Authorized in the FY20 NDAA. By the end of this September, over $5.5 billion will have gone through the Software Acquisition Pathway across the last three fiscal years.[12]
Rapid Defense Experimentation Reserve (RDER)	A new fund to help the DoD address joint, high-need capability gaps by partnering with the services to fund experimentation, operating in a sprint model based on capabilities, and more rapidly field capabilities. Congress appropriated $324 million for RDER in FY22 NDAA.[13]
Replicator Initiative	Announced in August 2023, "Replicator" focuses on delivering focus on fielding "thousands" of attritable autonomous platforms that will be characterized by being "small, smart, cheap, and many." This initiative will use "existing funding, existing programming lines, and existing authorities to accelerate production and delivery at scale.[14]

Concerns of "Innovation Theater"

With the expansion of innovation organizations in the last ten years, many policymakers and acquisition experts argue that these efforts amount to "innovation theater."[15] Also described as "innovation for innovation's sake," critics argue that this ecosystem mainly facilitates endless prototyping but doesn't actually field or deliver capabilities to the warfighter. Instead, many of the innovation initiatives are simply quick fixes that don't actually address the root regulatory and budget challenges that restrict agility and speed.[16] This is also a regular complaint from the commercial sector, particularly dual-use companies that want to work with the DoD but can rarely get past prototyping phases or into programs of record.[17] While well-intentioned, many innovation initiatives are not scalable across the services and end up facing the same roadblocks as mainstream acquisition initiatives – regulatory and budget constraints. There is an ongoing debate within the defense innovation community about whether the DoD should scale back and consolidate innovation initiatives or if the proliferation of innovation initiatives across the Department is an important marker of progress.

The Defense Department has heard the call from industry for more clarity for the commercial sector and better guidance for non-traditional companies on navigating the "defense innovation ecosystem." In 2022, the Pentagon launched an innovation ecosystem project to map the full universe of defense technology accelerator offices and programs, which included an Innovation Pathways Website – www.ctoinnovation.mil – that allows those inside and outside the Department to quickly connect with the innovation organizations best suited to their needs.[18] However, this "one-stop shop" leads to over 250 different innovation organizations, consortia, intermediary agreements, software factories, research centers, reinvention laboratories, and technology transfers. The screenshot below from the Pathways Website showcases the expansive ecosystem that can prove incredibly challenging (if not impossible) for start-ups and non-traditional DoD partners to successfully navigate. Addressing the concern of "innovation theatre," or even the DoD getting in its own way, is an important challenge to consider for successfully scaling critical technology within the DoD.

Figure 1: Screenshot from the Defense Department's Innovation Pathways Website



Enter Venture Capital: The Rise of Defense Tech Investing

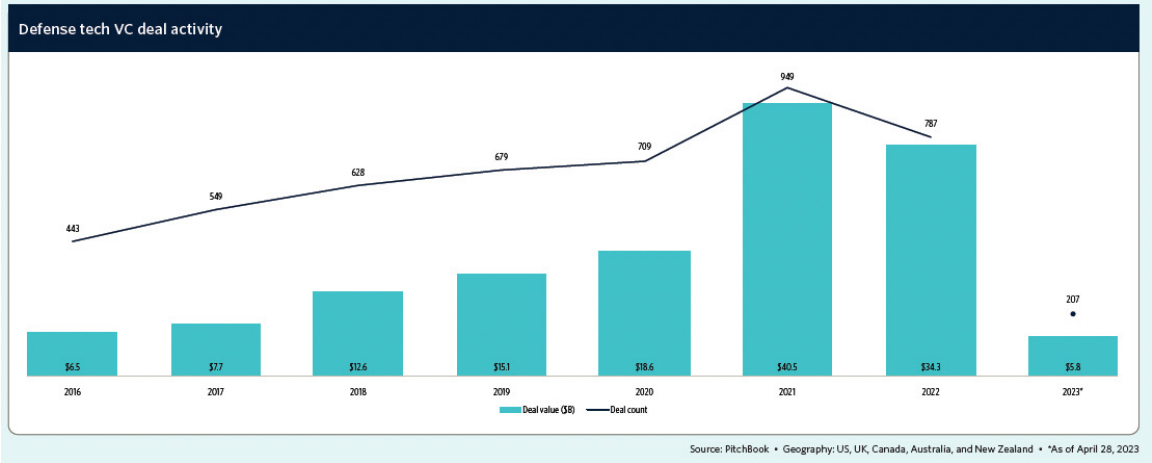
Despite the challenges facing the DoD's innovation ecosystem, the United States' enduring advantage over China is a thriving and open commercial industry. Silicon Valley and the U.S. venture capital (VC) ecosystem provide a strategic edge for 21st-century conflicts and great power competition with China. Silicon Valley is a critical counterbalance to the scale of China's technology investments and also supports the continual growth and evolution of the U.S. defense industrial base.

The U.S. defense technology private sector is expected to grow to $185 billion by 2027, driven by the changing geopolitical climate and the U.S. government's growing demand for innovative dual-use technologies to meet national security goals. Venture capital investing and deal activity are driving the sector's growth. From 2016 to 2022, $135.3 billion was invested across 4,744 defense tech deals. 71% of VC exits were acquisitions, which reflects the sector's consolidation and the strategic value of new defense tech companies to larger and more established industry players. [19] These capital flows underscore a burgeoning trend – the increasing convergence of VC and startups into the defense tech or dual-use market arena. With its extensive application of commercial and dual-use technologies, the war in Ukraine has amplified this potential, showcasing the opportunity and scale for venture investments. Since the start of the war, Ukrainian forces have leveraged cutting-edge dual-use technology from defense startups, showcasing the impact of innovative defense solutions in modern warfare.

In-Q-Tel (founded in 1999) pioneered the defense tech investment niche as the first VC to exclusively invest in defense-related or dual-use technology, albeit operating under a non-profit model. IQT's model was foundational for the current defense tech investment landscape that is rapidly growing today. Specialized defense tech VC firms, like Shield Capital, are instrumental in bolstering pure-play defense tech enterprises, channeling early-stage capital to these startups, and helping them navigate the perilous 'valley of death.' By bridging this initial funding gap, these firms are fueling innovations and shaping the future of defense technology. Generalist VC firms are also rapidly introducing and expanding defense technology portfolios – like Lux Capital or Andreessen Horowitz's American Dynamism practice.[20] VCs have had a successful track record in the

dual-use space and have backed companies like Anduril, SkyDio, and Shield AI, which have won and successfully scaled contracts with the U.S. government.[21] With a projected CAGR of 16%, the U.S. defense technology market represents a dynamic landscape and opportunity for investors and founders. The future of the defense tech industry is inextricably linked to the changing geopolitical landscape, and increased defense spending will drive further investments and collaborations between traditional defense contractors, tech firms, and startups.

Figure 2: Defense Technology Venture Capital Deal Activity Graph



Both Congress and the Defense Department have also taken steps to support and support this growth by providing early-stage, dual-use start-ups with additional capital. In 2021, Congress established the National Security Innovation Capital (NSIC), which identifies startups developing dual-use technologies and could benefit from government funding to develop their products and bring them to market. NSIC was authorized in the FY19 NDAA, given concerns that U.S. hardware startups were having trouble finding adequate capital from trusted U.S. sources, and were looking to Chinese-backed venture funds for additional capital. However, NSIC only had an initial budget of $15MM for FY23 and a total of $35MM from 2021 to 2023.[22] While the NSIC is an important signal from Congress and the DoD to startups, the funding must be further expanded to counter private venture capital from non-trusted sources. In addition to programs like NSIC, the Defense Department has continued efforts to harness private capital investments in critical dual-use technology, most recently with the launch of the new Office of Strategic Capital (OSC) in 2022. OSC is tasked with the mission of developing, integrating, and implementing proven partnered capital strategies to shape and scale investment in critical technologies.[23]

These initiatives are a step in the right direction for improving investments and encouraging more private sector and venture capital investments in dual-use and defense technology. However, if Congress and the Defense Department want to truly move the needle and maintain the U.S. military's technological advantage, regulatory and budget processes need a fundamental and significant change to continue encouraging the defense technology industry and provide opportunities for VC-backed companies to meaningfully scale through government contracts.

Lack of acquisition and budget agility is a national security threat

> "Our current system is too slow and too focused on acquiring systems not designed to address the most critical challenges we now face. This orientation leaves little incentive to design open systems that can rapidly incorporate cutting-edge technologies, creating longer-term challenges with obsolescence, interoperability, and cost-effectiveness. The Department will instead reward rapid experimentation, acquisition, and fielding."
>
> – National Defense Strategy 2022[24]

The U.S. military's investments in technological superiority have ensured U.S. military primacy since World War II. However, the proliferation and democratization of technology in the digital age have fundamentally shifted the threat landscape, allowing adversaries to leverage commercial technology to develop asymmetrical offensive and defense advantages.

The Department of Defense is now at an inflection point. It must make significant reforms to innovate and deliver advanced technologies and capabilities more rapidly, especially as China and others seek to erode U.S. global leadership. Despite this urgency, the DoD's acquisition system is not keeping pace in this digital age. The most advanced capabilities are no longer developed by militaries, but by commercial companies and private sector innovators. In fact, 11 of the DoD's 14 critical technology areas come from the commercial sector.[25] With a budgeting and procurement process that was designed in the 1960s, a new system for modernization is needed to maintain U.S. military supremacy and deter adversaries such as China and Russia.

> "China is organized like Silicon Valley, and the Pentagon is organized more like a Detroit automaker. That's not a fair fight."
>
> – Steve Blank, Stanford University[26]

Reforming defense acquisition processes and spurring innovation is critical in this era of great power competition. China has prioritized investments in the critical future technologies that will be foundational for advanced commercial and military applications: Artificial intelligence, robotics, autonomous vehicles, augmented and virtual reality, financial technology, and gene editing. Some estimates place Beijing's capital infusion into the tech sector at more than $1T.[27] The U.S. National Security Strategy has identified China as the "pacing threat," and the PRC's investments in advanced technology capabilities contribute to the growing threat to U.S. national security and the rules-based international order.[28] The Defense Department has recognized and taken action to address this threat by requesting the largest-ever innovation and modernization budget in 2023: $145 billion from Congress in fiscal 2024, which is an increase of about $15 billion more than FY23.[29] There is also some bipartisan movement from members of Congress to increase funding to the DIU and other similar initiatives to counter China's growing influence.[30] However, more urgency and greater investments are needed to see real breakthroughs. As these critical programs remain underfunded, the United States risks falling behind our adversaries in this era of rapid technological innovation.

III. Small Unmanned Aircraft Systems (UAS)

Capabilities for a future fight in an era of strategic competition

> "Autonomy weaves its way through most of the other technologies... and will transform the future landscape of the battlefield."
>
> – Association for Unmanned Vehicle Systems International

Research Scope Introduction: Why Small UAS?

The Defense Department has recognized the strategic and operational importance of autonomy in this new era of great power competition. However, the DoD's approach to scaling emerging and commercial autonomous capabilities lacks strategic clarity and direction. Furthermore, the "valley of death" between commercial companies and the DoD's acquisition and technology procurement institutions has only widened as technology has become more advanced in the commercial sector. This is particularly true for small UAS, where the commercial sector is developing the most advanced capabilities.

Within the broad field of autonomous capabilities, the urgent need for the rapid scaling of small unmanned aircraft systems (small UAS) has become clear in the wake of the war in Ukraine and increased tensions and competition with China. This report is scoped to focus on small UAS given the advanced autonomous capabilities, the unique challenges for scaling this type of technology, and growing strategic importance.

Small UAS capabilities present a unique challenge for scaling within the DoD's traditional acquisition processes for two primary reasons:

1. **Small UAS are software-enabled hardware;**
2. **The most advanced capabilities all exist in the private sector.**

Additionally, small UAS have important strategic implications for the United States:

- The United States' main strategic competitors are developing advanced small UAS capabilities. China dominates the global commercial small UAS market (over 70%), leaving the US at a significant disadvantage and indicating a critical need to build industrial base capacity.
- It's widely agreed that drones will be crucial in 21st century great power conflict as a method of deterrence and operations in a highly contested environment, raising important strategic questions for the use of small UAS in a great power conflict.

- The Ukraine war has showcased the advanced and critical capabilities from the rapid scaling and use of commercial small UAS in active conflict.

The following section outlines the small UAS scope of the report and discusses the strategic implications of small UAS for the Defense Department.

Defining Small UAS

This report uses the Department of Defense's basic definition for unmanned aircraft systems (UAS) as "powered aircraft that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload."[31] For this report, **"Small UAS" is defined as a non-lethal, unmanned aircraft system that weighs less than 55 pounds**.

As seen in the chart below, the DoD classifies UAS primarily by weight. This report only focuses on Groups 1 and 2, which are under 55 pounds. The Federal Aviation Administration also classifies small UAS as any unmanned aircraft under 55 pounds, so the majority of commercial drone companies and the case studies in this report subscribe to this classification as well. [32]

Figure 3: UAS Classification Chart

UASs Classification according to the US Department of Defense (DoD)

Category	Size	Maximum Gross Takeoff Weight (MGTW) (lbs)	Normal Operating Altitude (ft)	Airspeed (knots)
Group 1	Small	0-20	<1,200 AGL*	<100
Group 2	Medium	21-55	<3,500	<250
Group 3	Large	<1320	<18,000 MSL**	<250
Group 4	Larger	>1320	<18,000 MSL	Any airspeed
Group 5	Largest	>1320	>18,000	Any airspeed

**AGL = Above Ground Level **MSL = Mean Sea Level Note: If the UAS has even one characteristic of the next level, it is classified in that level.*

Source: "Eyes of the Army" U.S. Army Roadmap for UAS 2010-2035 • Created with Datawrapper

Autonomous Capabilities

However, there is some nuance when defining autonomous capabilities for small Unmanned Aircraft Systems. A small UAS typically requires some form of control from a human operator, whether that be a remote pilot or an operator who sets a pre-programmed mission before launch. These systems may be capable of autonomous flight but still require a human to initiate and oversee the operation. In contrast, many advanced dual-use drones are referred to as Small Unmanned Autonomous Systems (sUAS), autonomous systems capable of operating without the need for a human operator to control their flight. The system can make its own decisions based on pre-programmed instructions or inputs from sensors without the need for real-time human input. The key difference is whether there needs to be a "human in the loop" for any operation. This report will use the term small Unmanned Aircraft Systems instead of small Unmanned Autonomous Systems, as non-lethal capabilities used by the DoD require some level of human decision-making, even if they can operate completely autonomously.[33]

Evolution of Small UAS Capabilities

Over the past two decades, unmanned aircraft vehicles (UAV) of all sizes and capabilities have become a constant feature of modern warfare and will likely become even more important in the future, if current trends continue.[34] During the Global War on Terror, the United States utilized UAS/UAV capabilities to conduct intelligence, surveillance, and reconnaissance (ISR) and strike missions. The MQ-1 Predator drone is one of the first and most well-known examples of remotely piloted aircraft used in Afghanistan by the U.S. Air Force starting in 2001. With a unit cost of $20MM, the MQ-1 Predator was a critical and strategic technological advancement and military capability that shaped the U.S. engagement in the War on Terror and the identity of military drones.[35]

However, the last ten years have seen a radical shift in the technological landscape for unmanned aircraft systems from an expensive and sophisticated military capability to a readily available, popular, and affordable commercial technology. The U.S. commercial drone market alone grew from $40 million in 2012 to about $1 billion in 2017.[36] The global commercial drone market size is expected to hit around $47 billion by 2030.[37] As a result of commercial investment and innovation, drones have become smaller, cheaper, and more autonomous. The commercial sector has rapidly outpaced the Defense Department's own small UAS capabilities, particularly in advanced autonomy. This industry-government dynamic makes partnering with the commercial sector critical for acquiring advanced small UAS technologies at the speed of relevance.

Getting Left of Launch: Small UAS in a future great power conflict

In this era of great power competition, small UAS capabilities have gained critical strategic and operational relevance. Small UAS capabilities provide advantages that are important in highly contested environments, which will be the likely battlefield dynamic in a great power conflict scenario. As relatively low-cost but impactful capabilities, the U.S., China, and Russia have all integrated small UAS into their defense ecosystems to improve early warning, increase domain awareness, improve strike coordination, execute swarming maneuvers, and conduct information operations.[38]

With Xi's intent to prepare his forces to be prepared by 2027 for an invasion of Taiwan, the Taiwan Strait could determine the stability of the Indo-Pacific region.[39] In a conflict scenario in such a high-stakes arena, the strategic and operational implications of small UAS cannot be understated. In such a conflict zone, the U.S. needs cheap, scalable, and effective capabilities to raise the cost of invading Taiwan for China. Small UAS are a key part of the solution, and repeated U.S. war gaming consistently illustrates the indispensable role of these assets.[40] Networked swarms of drones, given their efficient ability to span vast territories, have emerged as key determinants in any potential conflict over the Taiwan Strait.

China's defense playbook for the Taiwan Strait revolves around constructing a dense, intricate web of aerial defenses, creating an environment of access denial for Taiwan and other adversaries. However, small UAS holds the potential to dismantle this strategy. Recent wargames from RAND and the Special Competitive Studies Project, that uniquely included members of the commercial technology sector, have provided compelling evidence in this direction. According to these wargames, large numbers of "low-cost, uncrewed air and maritime vehicles" can effectively confuse China's battlespace awareness. At a large scale, these drone mimics could cultivate the illusion of a more expansive coalition force, leading Chinese forces astray or wasting advanced munitions on incorrect targets.[41]

Drones — especially relatively inexpensive commercial drones — are an important new element that could complicate China's invasion plans. Rapidly scaling small UAS can help the U.S. with projecting air power in the Pacific. However, the People's Liberation Army (PLA) has also publicly identified small UAS as a strategic capability in a 'final unification war' on Taiwan and has made significant investments in these capabilities.[42] The PLA is leveraging China's civil-military fusion model as a key strategic advantage over the U.S. in scaling this capability. [43] China is home to the world's biggest drone manufacturer, DJI – which controls approximately 70% of the global drone market share. [44] With such a strong domestic industrial base, the PLA has been able to rapidly field and scale small UAS capabilities for military applications.

To combat China's current leadership in the commercial drone market, the DoD needs to rapidly scale UAS with more advanced autonomous capabilities to prepare for a possible great power conflict. U.S. companies like Anduril and Shield AI recognize this need and are prioritizing the development of small

UAS capabilities to operate in high-threat, contested environments, where U.S. air superiority is prevented by proliferated surface-to-air missile sites, GPS, and communications jamming.[45] Support from the U.S. government and DoD to foster a strong small UAS industrial base will provide the U.S. with the ability to catch up and overtake China's economies of scale in small UAS.

The Pentagon has recognized that the U.S. significantly lags behind China in small UAS scale and mass and has taken recent action through the Replicator program. Replicator aims to field "thousands of attritable autonomous platforms that will be characterized by being small, smart, cheap, and many."[46] While the capabilities covered by the program are much wider, small UAS is the exact type of technology that will benefit immensely from this program and is especially urgent, given China's sheer dominance and scale in the commercial drone market. With an ambitious timeline of the next 18 to 24 months, the Replicator program is a critical initiative to address the gaps between the U.S. and China in scaling critical autonomous capabilities and will hopefully lead to further scaling of small UAS capabilities to prepare the U.S. for a new era of great power competition.

A Strategic Asset: Scaling Small UAS in Ukraine

As discussed above, small UAS have strategic and operational imperatives in modern warfare. Nowhere are these more evident than with the use of small UAS capabilities on the battlefield by both Ukrainian and Russian forces. The war has underscored the strategic importance of drones in both reconnaissance and combat, demonstrating how commercial technologies can be seamlessly integrated into modern warfare tactics.

Despite the staggering financial disparities between Ukraine and Russia, the former's innovative approach has, in many respects, neutralized some of the conventional advantages held by the latter. Ukraine's significant investment in small UAS highlights the country's strategic vision and understanding of modern warfare dynamics. With a budget allocation nearing half a billion dollars and a successful fundraising initiative, "Army of Drones," that generated $1.6MM for a fleet of DJI Mavic 3T drones, Ukraine has pioneered an innovative method of warfare. These drones, equipped with state-of-the-art thermal imagers and zoom cameras, provide the Ukrainians with a tactical edge in spotting and neutralizing expensive Russian military equipment. [47]

Even with the battlefield evidence in Ukraine, there is still significant debate over whether small UAS are actually creating a revolution in military doctrine and tactics or if the effectiveness is greatly overstated, given how small UAS capabilities are extremely vulnerable in highly contested, GPS-denied environments.[48] While the initial phases of the war saw Ukraine employing drones effectively and with a first-mover advantage, the Russian forces responded with aggressive electronic jamming, disrupting the drone operators' communication signals. As a result, the Ukrainian military is actively working on software solutions to counteract Russian electronic jamming, showcasing the importance of simultaneous investments in advanced counter-UAS capabilities, alongside the expansion of a small UAS fleet.[49] This is an important consideration and challenge for the United States and other nations that are beginning to expand and scale small UAS as a strategic capability. Furthermore, domestic supply chains and a limited industrial base also curtail Ukraine's "Army of Drones" expansion efforts. While Ukraine is aiming to increase domestic drone production instead of importing foreign drones, the demand from the military far outpaces the current manufacturing capabilities.[50] Consequently, the Ukrainian military operates with a diverse range of drones from various manufacturers, leading to logistical challenges in training and operations.

Overall, the ongoing war in Ukraine has showcased how commercial small UAS technology has been able to outmaneuver expensive military systems and has been eye-opening for many in the defense acquisition community.[51] For other nations and potential conflict zones like Taiwan, the Ukraine war offers invaluable lessons on the integration and strategic deployment of commercial technologies in defense strategies. As the world watches Ukraine's resistance, it's clear that drones have become indispensable tools of modern warfare.

IV. Small UAS Case Studies

The following **three case studies** highlight different efforts and approaches by the DoD to develop and deploy small UAS technology. These case studies provided insights into the key factors that have contributed to the successful scaling of small UAS technology, and inform the recommendations in this report to advance this critical capability. This section analyzes the following three DoD programs:

1. **Defense Innovation Unit, Blue UAS**
2. **U.S. Navy, Task Force 59**
3. **U.S. Air Force, AFWERX Autonomy Prime**

Case Study 1: Defense Innovation Unit, Blue UAS

> "A holistic and continuous approach to rapidly prototyping and scaling capable and secure commercial UAS technology for the Department of Defense."
>
> – Defense Innovation Unit, Autonomy Portfolio[52]

The Defense Innovation Unit (DIU)'s Blue UAS program is the premier initiative across the Defense Department to accelerate the development and deployment of commercial unmanned aircraft systems (UAS) for military applications. As part of the DIU's broader Autonomy efforts, Blue UAS has a "holistic and continuous approach" to rapidly vet and scale commercial UAS for the DoD.

As its core mission, the DIU's Blue UAS program manages an extensive roster of policy-approved commercial UAS to serve the diverse needs of users across the DoD. The "Blue UAS Cleared List" is the central mechanism for updating, vetting, on-ramping, and increasing the pace of access to critical drone technology. The Blue UAS Cleared List has become a trusted resource for a broad range of capabilities across the DoD and helps address some of the major barriers that prevent the rapid scaling of commercial technology. Any drones on the "Blue UAS Cleared List" are Section 848 FY20 NDAA compliant, validated as cyber-secure and safe to fly, and are available for government purchase and operation, as they are on the General Services Administration (GSA) Schedule. Once vetted by the Blue UAS On-ramp effort, the commercial UAS capabilities do not need to go through certain exception authorities, which significantly reduces the administrative burden on end-users and companies.[53]

The Blue UAS initiative also has a line of effort that provides comprehensive information on relevant UAS resources in one central location for industry and government stakeholders, including the latest OSD and service-level UAS policy for commercial partners to easily track relevant requirements and processes. Through this line of effort, Blue UAS seeks to promote broader and greater participation from commercial partners in the overall DoD UAS ecosystem.

The Blue UAS initiative was created to address the dearth of approved drone capabilities for the U.S. military, specifically for the U.S. Army. Before 2017, Chinese-made DJI drones were "the most widely used non-program of record

commercial off-the-shelf UAS employed by the Army."[54] However, the U.S. Army banned the use of consumer drones made by Chinese manufacturer DJI in 2017 due to 'increased awareness of cyber vulnerabilities' and other significant security concerns. By FY20, the NDAA had codified an even more extensive ban into law and barred the Secretary of Defense from operating or procuring any UAS and related defense and national security equipment from China.[55] The Trump Administration also signed Executive Order (EO) 13981, which added additional cybersecurity specifications and purchase restrictions for commercial small UAS capabilities for military use.[56] While these were both important and necessary actions to protect U.S. military capabilities from Chinese influence, only one small commercial UAS product had successfully made it to fielding when the bans on Chinese commercial drones began.[57] Recognizing this massive gap for domestic UAS capabilities, the DIU team picked up the U.S. Army's Short Range Reconnaissance (SRR) program of record, "rapidly deployable, personal reconnaissance vertical take-off and landing sUAS for the dismounted soldier". The DIU team went to end-users across the DoD to survey what different services and units were needed from small UAS capabilities for their different missions and what each had the authority to buy directly. From these series of conversations, the team created the "Blue UAS 1.0" list, which sourced and approved NDAA/EO-compliant small UAS capabilities.[58] The initial drones on the "1.0 list" all met the Army's requirements in addition to broader set of mission needs and could be bought by partners across the DoD and federal government.

While the primary mission of Blue UAS was to create an approved and rapid purchasing pathway, the Blue UAS team also wanted to prove to other areas of the government that this type of initiative was possible.[59] Through Blue UAS, the DIU created a playbook for other areas of the federal government to replicate a "cleared list function" of commercial technologies for direct government purchase. Blue UAS is now in its second and broader iteration – Blue UAS 2.0 – and remains an unapparelled example of aggregating and amplifying demand for capabilities and providing rapid pathways within the DoD for scaling commercial technologies. Not only does the Blue UAS program assist vendors by pooling the demand from the DoD side, but the program also helps facilitate a more competitive U.S. industrial base for small UAS suppliers.

However, the DIU Blue UAS team is run by only a handful of people and needs significantly more funding to scale its cleared list and the Blue UAS lines of efforts. Given how UAS capabilities are used in countless and diverse ways across services and even within units, the Blue UAS effort has the potential to be handed off from the DIU and broadly scaled.[60] The DIU was the ideal organization within the DoD to launch this effort, given its remit to bring together commercial UAS companies with DoD partners. With the Blue UAS Cleared List now established, the largest users of the list's UAS capabilities (for example, the U.S. Army is one of the largest purchasers of small UAS on the cleared list) could have more bandwidth to manage it. One of the major challenges facing the current Blue UAS team is having the capacity to connect, market, and educate the more traditional acquisition workforce and other government officials on the Blue UAS Cleared List. A larger, more well-funded, and dedicated team within an acquisition unit could have more resources to expand this effort across the DoD.

The Blue UAS initiative stands as a testament to the potential of bringing together commercial innovation with defense needs, especially in the rapidly evolving domain of small UAS capabilities. By instituting a comprehensive and streamlined process for vetting and deploying drones, Blue UAS not only addresses immediate security concerns but also paves the way for fostering a competitive domestic UAS industry. However, as with many pioneering initiatives, it faces the challenges of limited resources and the balance of managing innovation at scale. The trajectory of Blue UAS, underscores the pressing need for increased investment, broader management, and more extensive collaboration to fully harness the capabilities of commercial technology for national defense.

DIU Blue UAS Case Study Findings:

1. **Effectiveness of Centralized Vetting Mechanism**: The "Blue UAS Cleared List" serves as an effective mechanism to continuously vet and update drone technology and avoid drawn out requirement approval processes. The list still ensures that the small UAS capabilities are still cyber-secure, safe for use, and in compliance with legal mandates. The streamlined process also notably reduces administrative challenges for end-users and vendors.
2. **Amplifying and Consolidating Commercial Demand**: A central purchasing hub and "cleared" list is an effective method for bringing

together the demand and supply side between government customers and commercial markets. The "Blue UAS 2.0" initiative exemplifies how to aggregate and amplify demand for advanced capabilities, streamlining the scaling process within the DoD for commercial technologies.

3. **Example of Agile Responses to Security Concerns and Regulatory Changes**: The Blue UAS initiative was established against the backdrop of emerging security concerns linked to foreign drone technologies, most prominently from China. This was compounded by a series of bans on Chinese drones, emphasizing the need for domestic and secure UAS capabilities.

4. **Success of Playbook Creation Model:** Blue UAS initiative is not just about drone technology; it's also about demonstrating a new approach to rapid vetting and procurement. The DIU effectively wrote a playbook for other government sectors, illustrating the feasibility of a "cleared list function" for swift government purchases of commercial tech.

5. **Recognizing Resource and Funding Constraints**: Despite its successes, the Blue UAS team grapples with resource constraints. The initiative, although spearheaded effectively by the DIU, might gain further traction if managed by entities with more expansive resources, such as larger acquisition units within the DoD.

Case Study 2: Department of the Navy, Task Force 59

> "Everyone is focused on the robots, but we are building a data infrastructure to support a place where we can exploit with AI and ML."
>
> – Commodore Michael Brasseur, Former Commander of Task Force 59[61]

Launched in September 2021, Task Force 59 (TF59) is a disruptive program within the U.S. Navy that brings together military and commercial technical experts to "deliver drones and artificial intelligence for advanced maritime operations."[62] Housed within the U.S. Central Command (CENTCOMM) and stood up by the U.S. 5th Fleet, TF59 is leading the integration of AI tech into unmanned systems within new domains.[63] With CENTCOMM's maritime-centric AOR, dual-use and military technologies partnering with TF59 are presented with a diverse range of operational challenges, including rough seas, hostile adversaries, and unpredictable weather.[64]

TF59 is a unique model that creates low barriers to entry for commercial partners and leverages the "design sprint" model (well-utilized in the commercial technology industry), which TF59 refers to as the "capabilities sprint model". The capabilities sprint model is a rapid testing cycle that "burns in" new technology and pushes the capability to the point of failure.[65] Through implementing this process, TF59's commercial partners are able to rapidly iterate through in-theater exercises, providing them with critical data points for improving their technology for military use and transitioning into a program.

As of February 2022, TF59 has conducted 20 exercises, facilitating over 35,000 hours of experience for commercial partners and Navy operators.[66] These exercises also produce important data for the Navy, which is leveraged for domain awareness, and broader strategic planning for data use in the Navy and other services. Throughout TF59's experience working with commercial partners, the team has found that the "as a service" service model is an appealing contract type for commercial small UAS/UUV.[67] From their experience, the "as a service" contract model allows the DoD to better leverage existing commercial autonomous capabilities that are largely software-based. Without a more flexible contracting type, the DoD can't rapidly scale autonomous technologies that require constant updates to be at peak operating capacity.

TF59 views itself as a strategic lever that works with other initiatives across the Navy and DoD that are working to scale autonomous technologies, particularly small UAS/UUVs. Additionally, the Navy has an Unmanned Task Force, which is pursuing the best acquisition methods for unmanned systems and data that are generated through programs like TF59.[68] Overall, TF59 is a critical example for other services to replicate as a means for more rapidly prototyping small UAS/UUVs.

TF59 Case Study Findings:

1. **Introduce Rapid Prototyping and Iteration Models:** Implementing the capabilities sprint model in government programs can be successful in pushing more rapid prototyping and preventing endless iteration. TF59 operates on the "capabilities sprint model," emphasizing the importance of fast testing and iterating technologies. This rapid prototyping approach allows the technology to be refined and enhanced efficiently.

2. **Provide challenging testing environments**: Commercial companies want more in-theater testing opportunities, as they generate important data and improve their products to better meet DoD operating standards. Launching TF59 under CENTCOMM's challenging conditions emphasizes the importance of testing technologies in real-world, complex scenarios, ensuring they are robust and ready for practical military applications.

3. **Support Flexibility in Contracting:** TF59 shows how "as a service" contract models can provide a direct and effective path for scaling small UAS/UUV capabilities. TF59 is very supportive of this model as one of the primary ways for scaling autonomy. The appeal of the "as a service" contract model underscores the need for flexible contracting. In a rapidly evolving tech landscape, having malleable contract structures like "as a service" contracts can be key to leveraging cutting-edge solutions.

4. **Gathering Data is Crucial:** The exercises undertaken by TF59 generate significant amounts of data for the services and commercial partners. This data is not just for improving technology, but also aids in broader strategic DoD planning and domain awareness.

5. **Replicate in Other Services:** TF59 serves as a model for other military branches, emphasizing its successful approach and the potential for its strategies to be adopted by other services in their quests for technological advancement.

Case Study 3: AFWERX Autonomy Prime

> "Autonomy Prime removes roadblocks that prevent rapid, affordable, and iterative testing of autonomy in aircraft, as well as potentially spacecraft and ground vehicles."
>
> – AFWERX Press Release, September 2022 [69]

The U.S. Air Force's innovation organization, AFWERX, has provided another important model and new case study for prototyping and scaling autonomous technologies. Announced in September 2022, the new AFWERX Autonomy Prime program will focus on engaging with companies that are developing advanced autonomous capabilities. Unlike a traditional acquisition program, Autonomy Prime will not set requirements but instead, look for possible adaptations to existing prototypes or autonomous technologies that could support Air Force missions. The key philosophy of the program is pushing for "collaborative risk reduction across the industry and military to accelerate the development and implementation of emerging technologies." [70]

The AFWERX Autonomy Prime program is unique because of its approach to prototyping and scaling. It begins with introducing challenges that are focused on key technology gaps identified by the Air Force. Companies then conduct demonstrations at proving grounds and directly with the end-users to compete for funding and the opportunity to transition into an official Air Force field capability. The proving ground is an important facet to address the challenge of rapidly prototyping technology, which often gets held up in the traditional acquisition process. Instead of field testing that could take years, the Air Force is providing physical locations for non-traditional defense companies to perform tests, along with digital twins for modeling and simulation work. This is a unique set-up that the program implemented from Agility Prime, AFWERX's first iteration of this model. Without this program, smaller or non-traditional companies working on autonomous technologies wouldn't have access to state-of-the-art testing facilities due to long approval processes or lack of funding.[71] For many new companies that are still developing their technologies, access to an advanced proving ground and physical testing location can be a ground-breaking opportunity for a nascent technology.

So far, the demand from start-ups and non-traditional defense companies to engage with the AFWERX Prime programs has been strong, and similar demand is expected for Autonomy Prime following its launch.[72] However, the next step is cultivating relationships with founders and companies and identifying the capabilities that are advanced enough to realistically scale into a broader program within AFWERX and the Air Force. While AFWERX Prime is still a relatively new initiative, it can provide a new pathway for smaller, more innovative companies to prototype and scale their capabilities.

AFWERX Autonomy Prime Case Study Findings:

1. **Importance of Access to "Proving Grounds"**: AFWERX Autonomy Prime offers unique access to testing facilities, both physical and digital, for startups and non-traditional defense entities. This not only fast-tracks the prototyping phase but also provides these companies with a rare opportunity they might not have had access to otherwise.
2. **Challenge-Based Selection Model**: Rather than following typical procurement procedures, AFWERX Autonomy Prime initiates technology-specific challenges. This model allows companies to demonstrate their solutions in practical scenarios, making the selection process more solution-oriented and specific to warfighter needs.
3. **Philosophy of Collaborative Risk Reduction**: AFWERX Autonomy Prime places an emphasis on fostering a mutual understanding and shared risk between the military and commercial industry partners, a philosophy that can be important to expedite the scaling of commercial and dual-use technologies.
4. **Opportunities for Early-Stage Companies**: AFWERX Autonomy Prime can serve as an entry point for smaller, newly-founded companies to both demonstrate and amplify their technological contributions to the defense partners through direct access to proving grounds and live demonstrations.
5. **Demand and Future Potential:** The high interest shown by startups and non-traditional defense companies toward AFWERX Prime programs indicates the effectiveness and appeal of such an initiative. However, the challenge remains in nurturing these partnerships and identifying the types of technologies that will successfully scale and align with the U.S. Air Force's operational challenges.

V. Key Findings

During the literature review and expert interviews, six hypotheses emerged regarding the major challenges the DoD faces when attempting to scale small UAS capabilities to the warfighter:

1. **Requirements Challenge**
2. **Culture Challenge**
3. **Metrics Challenge**
4. **Transition Challenge**
5. **Budget Challenge**
6. **Workforce Challenge**

Many of these findings also apply to the broader defense acquisition system and efforts to scale other autonomous and emerging capabilities. Ultimately, the challenges outlined in this section prevent the DoD from bridging the gap between the rapidly evolving threat landscape and the urgent need for critical and innovative capabilities.

Requirements Challenge

Requirement First, Warfighter Problem Second

The Defense Department's problem isn't a lack of innovation – it's a requirements process that has no flexibility for the iterative nature of commercial technology. In the current defense acquisition system, the requirements for the technology or program come first, and the warfighter's problem comes in second place.

The Joint Capabilities Integration and Development System (JCIDS) is the requirements creation and validation process that is the foundation of the defense acquisition system.[73] At best, JCIDS is a complex, disjointed bureaucracy across Joint Staff and the Services. At worst, it's a system that further distances the core problem from the requirement itself, leading to worse outcomes for warfighters and force readiness. JCIDS was created to support the statutory responsibility of the Joint Requirements Oversight Council (JROC), which validates joint warfighting requirements.[74] JCIDS plays a key role in identifying the capabilities required by the warfighters to support the National Defense Strategy (NDS), the National Military Strategy (NMS), and the National Strategy for Homeland Defense.[75]

For larger and more traditional programs like aircraft carriers or fighter jets, this complex requirement process is an important framework that gives the DoD more direction over the development of its most advanced and expensive capabilities. However, the complex requirement generation process is mostly obsolete for buying and fielding commercial technologies, where the market has already advanced far beyond current DoD requirements. The existing defense acquisition system *forces* a requirement – whether one is needed or not.[76]

This is particularly true for small UAS capabilities. The rigid, exhaustive specifications for products developed throughout the requirements process prevent the DoD from rapidly accessing drones with advanced capabilities in the commercial market, regardless of warfighter demand.[77] As an emerging (although commercially established) capability, small UAS do not have a robust operational requirement structure like other traditional military technologies in the defense acquisition system.

Because the rigid requirements structure demands every technology to fit within exact specifications, the DoD gave much of the requirement responsibilities of drones to Aviation PEOs across the different services. As a result, many small UAS capabilities are put through the same level of testing, oversight, and requirements as more complex and expensive aviation capabilities. This level of rigor is unnecessary for an unmanned aircraft that weighs less than 55 pounds. However, there is no alternative process for PEOs and other acquisition officials.[78]

In addition to the testing requirements, there is a host of additional milestones for acquisition officials to cross: SOPs, back-end delivery, maintenance, training procedures, and more. Given that small ISR assets are new at the tactical and organic unit level, program offices need to institute new training processes for small UAS capabilities. Most of the time, the program offices rely on extensive training procedures for more complex aviation technologies that are unnecessary for an easy-to-operate commercial drone. The many requirements for training servicemembers on new capabilities add time and cost to scaling a small UAS program and can lead to funding delays, making it more difficult for the program to scale.

Small UAS manufacturers who want to sell to the DoD are also held to high cybersecurity standards to gain "authority to operate."[79] The NDAA and Executive Order 13981 have set extremely rigorous testing and security standards that are not relevant or necessary, given commercial advancements and use-cases, for small UAS manufacturers. While robust cybersecurity standards are essential for dual-use technology, many in the small UAS private sector industry argue that the cybersecurity standards are outdated for the advanced commercial capabilities and are actually preventing the U.S. from competing with China, instead of protecting U.S. military assets.[80]

Small UAS capabilities are caught up in standards and requirements that don't make sense for the core functionality of the technology, which leads to adverse outcomes and delays in critical technology for the warfighter. Fundamentally, there is no alignment between the problem the warfighter is facing and the "solution" that is created through extensive requirements.

Culture Challenge

What matters more – authorities or culture?

Interviews and case studies showcase that a significant barrier is organizational culture – not a lack of innovation initiatives and flexible contracting authorities within the DoD. This raises the question of whether culture makes more of a difference than adding more authorities for rapidly scaling emerging capabilities.

The Department's acquisition workforce and culture have been built and shaped by the Planning, Programming, Budgeting, and Execution (PPBE) process. Even with the proliferation of more flexible funding authorities, innovation hubs, and attempted reforms, the DoD culture prevents the scaling of emerging or dual-use capabilities that warfighters need in this new era of strategic competition.

No incentive for risk-taking, even with flexible authorities: The primary cultural challenge is the incentive structure for acquisition officials. Acquisition officials are not incentivized to take risks and exercise the authorities granted in both the Federal Acquisition Regulation (FAR) and with newer authorities. For many seasoned acquisition officials, taking risks could mean significant consequences for superiors (a Congressional hearing, external investigations, etc.) regardless of what the authorities may allow.[81] As described in an interview, this can be a "one-mistake game."[82]

For example, a major complaint from non-traditional companies is how the DoD's acquisition system prevents connections with program managers and contracting officers. While prime contractors and more traditional vendors have long-standing relationships, non-traditional vendors and start-ups looking to sell to the DoD have very few entry points. Innovation hubs like the Defense Innovation Unit and AFWERX were created to build more connections between PEOs and program managers in the services overseeing large programs. Although FAR 10 (which grants authorities for vendor outreach) is quite liberal in allowing direct outreach to vendors, the cultural divide and lack of incentive to engage directly or through these innovation hubs remain strong.[83] As a result, many non-traditional vendors end up applying for contracts that they were never actually competitive for, adding further tension and distance between the defense acquisition workforce and innovative start-ups and companies who are eager to work with the DoD.[84]

One of the primary drivers of this culture is often a pervasive fear of both legal liabilities. Contracting officers can be held liable for components of their contracts, which leads to huge risk aversion to use any flexible acquisition authorities. [85] As a result, there is little incentive to try new processes or leverage non-traditional authorities. Program managers have been incentivized to see their role as "de-risking" programs instead of being empowered to use a creative blend of acquisition authorities to bring innovative technology, like small UAS, into programs or to servicemembers.[86] For example, Other Transaction Authorities (OTAs), which are lauded by many in the defense innovation ecosystem as the key to funding innovative technologies, were actually created in 1958, they have only recently begun to proliferate across the DoD. The Defense Innovation Unit uses OTAs as its primary acquisition authority, but the mainstream acquisition workforce is hesitant to fully leverage this flexible funding tool.[87] Why? First, OTAs are an entirely blank slate that many contracting officers believe would open them up to risk. Second, the training and incentives from leadership to use OTAs have also been limited. OTAs are important for scaling new capabilities like small UAS that are joint-capability.[88] However, with no proper incentives for contracting officers or PMs to use flexible authorities, it's nearly impossible for the DoD to move at the necessary speed for innovation and leverage existing authorities to scale critical technology like small UAS.

A culture made for big programs: Scaling emerging capabilities like small UAS must not only face a culture created by extensive requirements, but also compete in a culture shaped by traditional DoD acquisition programs.[89] Compared to the massive programs of record that produce aircraft carriers and fighter jets, the incentives for program managers or contracting officers to pursue smaller, more agile technologies like small UAS are minimal. If units want a unique or non-traditional capability, they must compete against larger PORs that the acquisition workforce is expert at maintaining and executing. Advocating for funding outside of lucrative and established PORs is an uphill battle for innovation hubs and units that want small UAS capabilities. Attempts at scaling programs for small UAS capabilities don't have enough buy-in or senior leadership to compete with the larger, more established programs that have existed for decades.[90] This cultural bias toward large, traditional programs is clear in the NDAA budget requests. Despite commitments to a force redesign by 2040, the Army's largest funding request in NDAA FY24 was still for more

tanks.[91] Tanks are not the strategic asset needed to win in a possible fight with China, but the strong acquisition culture that favors large and well-established programs endures. To equip U.S. forces with agile and innovative capabilities, the cultural favoritism, skill sets, and incentives to procure outdated capabilities must change.

Leaders make or break innovation: The success of any new authority, innovation hub, or dual-use technology program hinges on the advocacy from senior DoD leadership to make it happen. As a consistent theme across all interviews, innovative technologies like small UAS capabilities cannot be scaled without DoD leadership providing support for PEOs and contracting officers who want to rapidly pursue small UAS programs. Within the defense innovation community, the Mine Resistant Ambush Protected Vehicle program (MRAP) remains a critical example of the power of leadership to rapidly drive innovation and save lives.

Up until mid-2008, about 75 percent of casualties in combat operations in Iraq and Afghanistan were due to improvised explosive devices (IEDs), as the majority of U.S. soldiers only had flat-bottomed Humvees that used sandbags as a shield against IED blasts[92]. The MRAP – a newer armored vehicle with a V-shaped hull able to deflect blasts – had high life-saving potential, but the program had been held up by DoD acquisition bureaucracy. In response to the growing casualties and obvious capability gap, Defense Secretary Bob Gates took decisive action to rapidly scale and deploy the MRAP to warfighters. He announced that the MRAP acquisition would be the Pentagon's highest priority, and oversaw the immediate establishment of an MRAP Task Force. The task force was mandated to integrate planning, expedite the acquisition, and oversee rapid deployment and brought together key actors from across the Department and acquisition community, including stakeholders from USD(R&E), USD(A&S) and the different services. Within a year, 2,400 MRAP vehicles had been produced and fielded, scaling production capacity from a mere 82 vehicles per month in June 2007 to 1,300 per month by December 2007.[93]

The MRAP program was the first major military acquisition to transition from decision-making to production within a year since World War II.[94] However, the MRAP leadership model is not easily scalable. The MRAP program's rapid success was facilitated by a set of unique circumstances, including almost

unlimited budget allocations and the availability of mature technology ready for rapid production and deployment. Despite these distinctive factors, the MRAP case still underscores the importance of decisive leadership to cut through red tape to meet urgent requirements and has become a reference point for new initiatives in rapid acquisition, such as the Army's Rapid Capabilities Office. The MRAP program's monumental success showcases the impact of effective leadership in driving the DoD's capability for rapid innovation to meet urgent operational needs.[95]

Metrics Challenge

Defining "Mission Success" for Scaling Small UAS Technology

Every actor in the "defense innovation ecosystem" has their own metric for success. As a result, key stakeholders are not aligned to a shared mission of pushing promising technologies through the acquisition pipeline to be fielded to the warfighter. As a new and critical capability, small UAS are particularly susceptible to this lack of shared vision and metrics.

Fielding small UAS capabilities has been drastically slowed by the lack of alignment and metrics of success across the DoD. Each defense innovation organization, service, and acquisition authority in technology fielding has different measures of success that prevent an integrated approach to scaling a capability that is needed across all services. For entities like the DIU, AFWERX, or the Strategic Capabilities Office, their mission is getting the capability directly to the warfighter.[96] In contrast, PEOs and contracting officers often see their mission as minimizing all potential risks for any program and strictly following requirements for existing capabilities instead of being distracted by the "next flashiest thing." [97]

Given how many stakeholders engage in the technology prototyping and scaling process, it's very challenging to define a consistent success metric within the DoD to measure successful innovation or scaling. As technology gets handed off to different organizations, the metrics for success change, and incentives do not align with delivering technology rapidly to the warfighter. Through the PPBE process and reporting requirements to Congress, programs track obligations and expenditures but don't need to show if the money moved the program along in a meaningful way. This makes it difficult to understand what "success" looks like for larger, existing programs and to justify moving funding away to more innovation or small

technologies. [98] The lack of clear metrics of success from traditional communities ultimately impedes small UAS technology transition and contributes to the "valley of death" problem.[99]

Additionally, stakeholders are not aligned with a shared mission of pushing promising technologies all the way through the acquisition pipeline. The DoD has more diffusion of responsibility than any other organization. As Undersecretary Heidi Shyu said, "It's like being in a bus where everyone has a brake and can stop."[100] Each step of the technology acquisition and fielding process is distributed across different offices for each requirement, and often with varying sources of funding that require oversight from other areas of the DoD. This diffusion makes it challenging to find a metric that policymakers and senior DoD officials can use to measure effectiveness for scaling and fielding innovative technologies. Despite all the data that is created across this long process, the diffusion of responsibility makes it difficult for any central authority to combine and analyze this data as a possible way to measure success. It also makes tracking various technology initiatives across the DoD challenging. This is particularly true for efforts to scale autonomous technologies across the DoD, as there is no shared vision for small UAS fielding or the ability to track success.

Transition Challenge

Transition Definition: A shift in responsibility or ownership of the technology product or system to a PM/PEO, program of record (POR), or an operational unit for production, fielding, operations, maintenance, and/or support activities.[101]

Prioritization and Funding for Small UAS Technology Transitions

As defined above, a technology transition is one of the best measures of success for the defense innovation ecosystem. A transition into a POR allows for services and units to use a new capability and is also critical for securing revenue for the company or vendor providing the capability. Without a successful transition, innovative and new capabilities cannot be scaled to the warfighter and will remain either in a prototyping cycle or be dropped in the next budget cycle entirely. Consequently, non-traditional commercial companies and DIOs view technology transitions as the most critical hurdle to overcome.[102]

Despite the importance of technology transitions for fielding emerging capabilities, there is a critical lack of access to funding for dual-use technologies to be transitioned into sustainable programs. Technology transition is delayed by several key factors. First, the complex PPBE process means that many services or programs do not have available or unallocated funding to spend on a new technology transition that hadn't been written into requirements years beforehand. Second, technology transitions are not rewarded or often considered a metric of success by the mainstream acquisition workforce or services. PMs and PEOs need to go out of their way to identify creative sources of procurement dollars to transition a new technology into their programs and are not rewarded for this work.[103]

However, some technologies are easier to transition than others. PEOs can more readily transition software programs, as they are well capitalized by private industry, have the least capex for productization, and can go through the Software Acquisition Pathway.[104] As a result, software capabilities are the most likely to make it across the finish line and transition into a program, even with the challenges of finding procurement dollars. However, physical systems are much more challenging and expensive. As a software-enabled piece of hardware, small UAS capabilities fall in between categories and struggle to be transitioned from prototyping exercises into funded programs. Given the advanced capabilities and maturing of the small UAS commercial market, companies do not need years of prototyping funding or to be part of an OUSD(R&E) accelerator – they need a secure program or contract for a clear pathway into the DoD.[105]

Part of the Defense Innovation Unit's core mission is to address this challenge and facilitate transitions for non-traditional companies and start-ups into a production or service contract with the DoD. In FY22, the DIU had a historic 46% transition rate.[106] The DIU's Blue UAS program and "Autonomy" line of effort have been important milestones for fielding small UAS capabilities. Across both programs, the DIU has successfully transitioned 11 UAS company partners. However, the DIU still faces the challenge of finding a "transition partner" in a service that is willing to find a program element or line item in its existing budget to transition the capability into a program of record.

Created in the FY16 NDAA, Section 804 Mid-Tier Acquisition (MTAs) Pathway is one reform that aimed to create funding pathways to improve transition processes for advanced and mature prototypes.[107] As a nontraditional acquisition pathway,

MTAs have helped with some funding gaps, but not enough acquisition officials are comfortable using the new authority at scale (see: Culture Challenge) for rapid fielding.

Authorized in the FY22 NDAA, the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) new pilot program, Accelerate the Procurement and Fielding of Innovative Technologies (APFIT), also aims to address this gap in transition funding for innovative capabilities.[108] Congress gave APFIT $100 million in FY22, to be given to ten DoD program offices to buy capabilities from non-traditional vendors or small businesses. Two UAS capabilities were selected for a $10MM award in 2022. However, APFIT is still too small to address the transition funding challenge on a meaningful scale.[109]

Similar to entities like the DIU, the defense acquisition community needs to be unified by a "transition mentality."[110] Building this mentality requires better incentives for Contracting officers and PMs to look for opportunities to transition technology and for Congress to match the urgency of bringing critical technology out of prototyping funding cycles and into technology transitions. Until then, small UAS capabilities remain stuck in prototyping exercises instead of being fielded to warfighters.

Budget Challenge

A Defense Budget for the 20th Century – not the 21st.

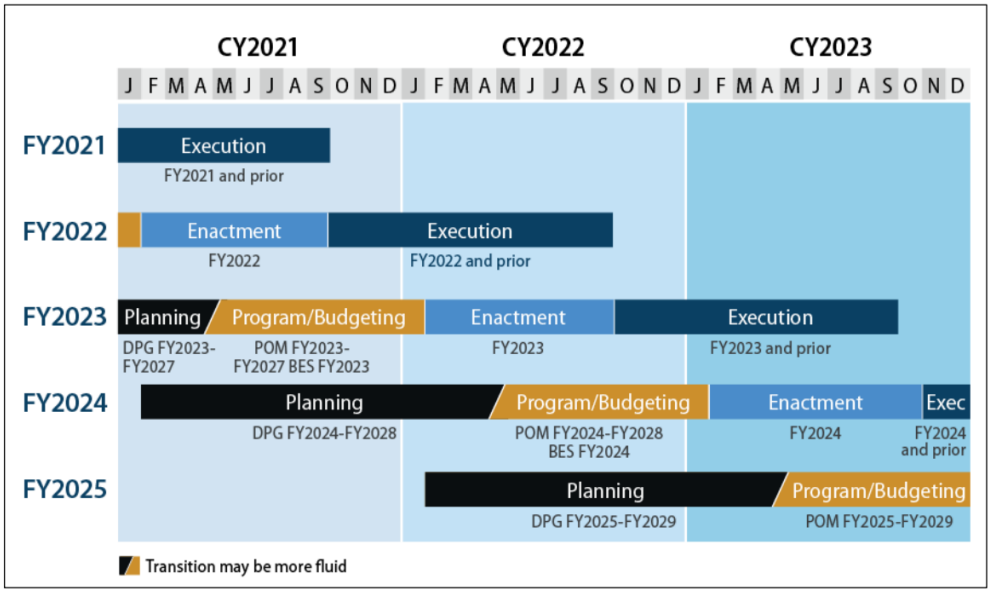
> "The fundamental problems with our defense budgeting process is that we take 2 1/2 years to program each dollar we spend."
>
> – Mike Brown, Former Director of the Defense Innovation Unit (DIU)[111]

The DoD's budgeting process was built for and designed for the Cold War. Designed in the early 1960s, the Programming, Planning, Budgeting, and Execution (PPBE) process is the basis for modern defense budgeting. It was originally created for OSD to exert control over the different military departments to align spending to focus on a main threat – the Soviet Union.[112] The U.S. military now exists in a world of far more complex and less predictable threats, in addition to a peer adversary that is far more advanced than the Soviet Union. At its core, the defense budget's lack of speed and agility is a national security threat.

Across the majority of interviews, the budget process was described as the crux of the challenge to rapidly field and scale emerging capabilities like small UAS. Within the PPBE process, the consensus was that timeline and flexibility were the two most significant challenges.[113]

Timeline: As a result of the PPBE process, the DoD is currently making its strategic budgeting plans for FY25 and FY26. While this process was initially created to force cohesive strategic planning, the technological landscape has vastly changed since the 1960s. In the 21st century, it's next to impossible to account for changes in the technology landscape years in advance. For example, the allocations for the current defense budget were decided on in 2019, and few would have imagined how commercial drones have become a critical capability in a great power war. The figure below shows how the PPBE process drags over several years, with the current programming and budgeting happening for FY25 – FY2029.[114]

Figure 4: Fiscal Year Cycles in the PPBE Process



Source: Figure created by CRS based on DAU references.

Notes: Timeline is notional. CY is calendar year; FY is fiscal year. Execution as shown is based on appropriations available for one year.

Flexibility: The rigidity of the defense budget prevents DIOs and AOs from directing funding transition into new capabilities. In the most recent NDAA, there are approximately 3,000 line-item appropriations stating exactly where money must be spent and that it can't be moved. Referred to as "colors of money," each dollar is appropriated into a specific category of spending, which restricts services from reallocating or moving money to different programs in the following years.[115] This

rigid categorization makes it very difficult for services or programs to reallocate funding to more innovative technologies that may emerge or become more relevant over several years.[116]

Trust: The "trust gap" and sometimes tense relationship between the DoD and Congress also adds complexity and delays the budgeting process. As the authorizers and appropriators, Congress plays a central role in the defense acquisition and innovation ecosystem and is legally obligated to provide oversight to DoD spending. While the DoD has long advocated for more flexible funding authorities, Congress has rightly exercised its oversight authorities to ensure that taxpayer money is being appropriately spent. However, the consensus across the national security community is moving toward the opinion that the current budgeting process is leaning too far to the side of intense scrutiny. [117] The major challenge is finding the balance between constructive oversight and a more agile and flexible approach to defense budgeting that equips the U.S. military with an evolving threat landscape.[118]

In FY2022, Congress also created a commission to study the effectiveness of the PPBE process in view of concerns over the pace at which the U.S. military is fielding commercially driven advances in software and other emerging technologies—such as hypersonic weapons, artificial intelligence, and 5G mobile technologies—relative to China and other strategic competitors. [119] This reform commission is a critical sign of progress, but any significant change is still many years out. Furthermore, the current domestic political landscape and tensions on the hill make significant PPBE reform in the next several years unlikely.[120]

Scaling small UAS capabilities has been greatly impacted by both the timeline and flexibility challenges in the budget process. As software-enabled hardware, the tight restrictions and "color of money" allocations have made it difficult for acquisition officials to find funding through traditional acquisition pathways. Furthermore, small UAS capabilities have significantly advanced in the last 3-4 years since the PPBE process began for the current budget cycle in FY22 and FY23. As a result, many small UAS programs were funded with R&E dollars in FY22 instead of being transitioned into programs.[121]

Ultimately, the DoD needs a defense budget that more adequately reflects the rapid technological evolution of the 21st century. Without a better process, the U.S. will remain behind our adversaries in preparing our armed forces for future conflicts.

Workforce Challenge

Acquisition Workforce Development for Modern Capabilities

On a fundamental level, the DoD needs a human capital strategy for recruiting, developing, and retaining talent in emerging science, technology, and innovation-related national security issues. This is particularly true within the DoD acquisition workforce, which would benefit from additional commercial, software, and product development experience.[122] As technology has rapidly advanced, the DoD's training, guidance, and tools for navigating a new era of military capabilities continue to fall behind.

The ongoing war in Ukraine has showcased the strategic importance and proliferation of drone capabilities to both allies and adversaries. However, unlike traditional military technologies, the most advanced small UAS capabilities are developed and owned by the commercial sector.

As a result, the DoD can acquire small UAS capabilities at a much greater speed and lower cost through commercial acquisition. However, significant investments are needed in workforce development to empower AOs to better leverage existing and unique contracting strategies. Currently, acquisition officials have not been given enough associated training to rapidly harness commercial solutions like small UAS without fear of exposing themselves to liability. [123]

The flexible authorities for scaling small UAS capabilities exist, but acquisition officials are not getting the right training and exposure to use these tools with confidence. For example, new acquisition vehicles such as the Middle Tier of Acquisition (MTA) and the Software Acquisitions Pathway are designed for acquiring more advanced hardware and software technologies.[124] OTAs are also a blank slate for contracting officers to leverage when negotiating with the private sector. However, without proper resourcing or experience, AOs are not incentivized to take risks on more innovative technologies or contracting authorities.

The DoD currently processes approximately 64 million contract actions annually and engages with over 300,000 contractors.[125] With such a significant workload, the acquisition workforce needs to be supported with more professional development and training to integrate creative and new authorities into existing programs and processes.

The DoD's Own "Valley of Death": While the last ten years have seen a proliferation of defense innovation hubs and organizations, the DoD's core acquisition workforce still operates and remains largely disconnected from these initiatives.[126] This disconnect is reflected in the low technology transition rates for innovation projects and hubs to programs of record.[127]

This disconnect comes down to culture and incentives. PMs are not incentivized to work with entities like the DIU unless they are particularly motivated by a certain technology or capability that their senior leadership is asking for. Already overburdened by bureaucracy, the traditional acquisition workforce is not able to track the latest advancements in commercial technologies, like small UAS. As a result, the responsibility lies with the innovation hubs or entities like the DIU to build more connections to PMs and educate contracting officers on commercial technologies that would help meet a requirement or end-user need.[128] If a Program Office is aware of a capability and its end-users are excited about it, it becomes much easier to collaborate to find transition funding and exercise more flexible contracting authorities. However, without more bridges to program offices, technology transition rates will continue to remain low.

The DIU's Blue UAS program has been helpful in spreading awareness about commercial small UAS capabilities within the defense acquisition workforce. The program's goal and success in placing drones on the GSA schedule have also helped alleviate misconceptions (driven by China's DJI) about the cybersecurity and reliability of commercial drones.[129] However, the Blue UAS program is only run by a handful of people and is too small to educate the acquisition workforce at scale. It remains significantly under-resourced, leaving very little room for the small UAS capability to scale across the Department. Convincing PMs who run large and complex programs to set aside money or take a risk on "innovation" requires much closer connectivity and trust between the innovation hubs and the core acquisition workforce. The DoD needs to equip the traditional acquisition workforce with the skills and opportunities to connect with innovation hubs. While the "Valley of Death" typically refers to the gap between the DoD and the commercial sector, it could easily refer to the gap between defense innovation organizations and traditional acquisition officials.

VI. Policy Recommendations

Informed by analysis from **55** expert interviews and small UAS case studies, the following recommendations aim to provide solutions to address the six key challenges outlined in this report. Through these recommendations, DoD senior leadership, national security policymakers, and Congress can close the capability gap for small UAS and emerging capabilities more broadly.

To do so, the Department of Defense should take the following actions:

1. **Create a Small UAS "Portfolio" or "Capability of Record" for Small UAS**
2. **Expand authorities and pathways to enable "autonomy as a service" contracting authority for Small UAS**
3. **Strengthen the U.S. Small UAS Industrial Base**
4. **Improve Acquisition Workforce Development and Innovation Connectivity**
5. **Prioritize Small UAS User Feedback**

Criteria for Policy Success: Each recommendation is evaluated based on the following criteria for its success and impact, in addition to potential challenges.

- **Fast Follower:** How well does this recommendation further the Defense Department's goal of being a "fast follower" and moving at the "speed of relevance"?[130]
- **Culture**: How well does this recommendation support broad culture change or paradigm shifts within the defense acquisition ecosystem? How does it encourage or support productive risk-taking?
- **Political Feasibility**: How likely is this recommendation to be supported by Congress? What are the possible concerns from Congress and challenges to address?
- **Timeline**: How long does implementing this recommendation take? What could advance or delay the timeline?

These criteria were developed based on the major takeaways and shared themes across the six key findings, interviews, and case studies.

Recommendation 1: Create Small UAS "Capability of Record"

Addresses Challenges:		
Requirements	Culture	Metrics
Transition	Budget	Workforce

Small UAS capabilities should be managed through a portfolio model, as opposed to the current program-centric model. Instead of the traditional "Program of Record" model, **a small UAS "Capability of Record"** portfolio approach will promote strategic direction by facilitating more rapid scaling, faster timelines, flexible spending, and agile procurement. Furthermore, a portfolio model can more efficiently deliver an integrated suite of small UAS capabilities to warfighters with greater cost effectiveness and interoperability.

Given the rapid speed of technological innovation, there is an urgent and well-established need for developing strategy-driven budgets and capabilities.[131] Small UAS is the ideal capability to launch the portfolio budgeting approach, given its cross-domain abilities and urgent operational needs. Additionally, the current war in Ukraine has demonstrated the strategic importance of small UAS capabilities and provided an important window of opportunity to advocate for this new funding model to Congress.

Recommended Action Items:

- USD(A&S) to establish a "portfolio of record" to own the integration of small UAS capabilities to maximize organizational agility, acquisition efficiencies, and mission impact.
- In the next NDAA, institutionalize APFIT and increase the funding to $300MM, which will provide transition funding for existing small UAS prototypes into the new small UAS portfolio of record.[132]
- Create and appoint Portfolio Executives to oversee the "Unmanned Portfolio" of Record that would include a team of acquisition officials, civilian, and uniform staff from across services, and a representative from the DIU Blue UAS team.

- Reform the traditional program requirements process, and instead use a rapid validation of needs process that identifies if the capability fits within the portfolio but also maintains Congressional oversight and engagement.
    - For small UAS, rapid validation for portfolio funding would be based on weight, speed, and other measures of the drone's capability in the field. Modeled after the DIU Blue UAS model, companies can also be certified or "pre-approved" for purchasing through the portfolio model.
    - To maintain Congressional comfort and oversight, the Portfolio team must submit the rapid validation criteria to Congress for review and a report every 90 days that outlines any new approvals based on the rapid validation model.
    - Commanders or units can directly request small UAS capabilities, similar to how foreign countries make security cooperation assistance requests.
- Establish Commercial Liaisons (similar to a DIU model) within the portfolio who manage proactive outreach with the private sector and share the new contracting opportunity through the portfolio mode.
    - Commercial liaisons work with the DIU Autonomous Line of Effort and Blue UAS program to transition existing prototypes into the small UAS portfolio.

Criteria Evaluation:

- Small UAS is well-suited for the portfolio model given its overall lower cost, concentration in the commercial sector, advanced capability and maturation as a technology, and cross-domain functionality and need.
- Through this structure, the DoD can adopt a more flexible approach to acquisitions and react with more agility to changing circumstances and capabilities, maintaining a competitive edge.
- Portfolio practices enable greater speed, as opposed to the requirements process that slows innovation. In this model, the DoD will not need to

make detailed specifications for products the commercial market already builds.[133]

- A portfolio approach is a significant step towards the successful implementation of the DoD's "Fast follower" approach, which was outlined in the Biden Administration's National Defense Strategy and has long been the goal of the DIU.[134] Instead of putting all efforts into a single small UAS program, the portfolio model allows for a less rigid model that doesn't punish contracting officers or PMs for a program that doesn't succeed given it is hedged with a larger portfolio of capabilities.
- Conveys a clear demand signal to the commercial market that there are more rapid pathways for scaling with the DoD.

Key Implementation Challenges:

- **Congressional Trust:** Portfolio budgeting can be seen as a "slush fund" for unchecked DoD spending and would require a close partnership with Congress to build trust and comfort with this new spending mechanism and requirements model.
- **Implementation Timeline:** Portfolio/capability budgeting would completely change the budgeting process between the DoD and Congress for buying capabilities, which would require either a significant regulatory overhaul or expansive pilot authorities that will likely take several years at best. However, the ongoing war in Ukraine provides a unique window of opportunity and urgency to counter this timeline challenge.
- **Training**: Creating a new acquisition official and authority, in addition to staffing the portfolio workforce, will require significant coordination with existing training authorities and the DAU.
- **Strategic Planning Process**: Introducing a portfolio of record models will require significant planning and coordination from both Congress and across the DoD, which will take time and complex stakeholder coordination.

Recommendation 2: Expand authorities and pathways to enable "autonomy as a service" contracting authority for small UAS

Addresses Challenges:		
Requirements	Culture	Metrics
Transition	Budget	Workforce

The "Autonomy as a Service" model is a critical part of the solution for rapidly scaling autonomous technology and delivering autonomous tech directly to the warfighter/end-user in a sustainable and long-term way.

"As a service" models are a well-defined procurement approach that is typically used to acquire capabilities and services on an as-needed basis rather than through traditional, long-term contracts.[135] Similar to a commercial subscription model, this contracting vehicle is used by the DoD for cloud or software-based contracts and allows contractors to provide services or capabilities that are made available to the Department in a scalable and flexible way.

The leading American small UAS companies consider themselves software companies – not hardware producers.[136] As an autonomous and software-enabled technology, small UAS software is constantly evolving with new updates to both expand capabilities and address software bugs. As a result, the DoD must empower the "as a service" model as the most effective way to rapidly leverage the most advanced small UAS capabilities, which are all in the private sector.

Recommended Action Items:

- USD(A&S) and Senior Acquisition Executives (SAEs) task-relevant stakeholders with identifying how the "as a service" contract pathway can be implemented for small UAS capabilities.
- DIU launches strategic outreach to small UAS companies engaged in their Autonomy Line of Effort and Blue UAS program for possible transition or eligibility for "as a service" contracts.
- Deputy Secretary instead of "Dep Sec Def" to direct the Defense Innovation Board (DIB) with investigating a policy approach to

expanding "as a service" funding and what Congressional action would need to be taken to give contracting officers more flexibility and security to pursue "autonomy as a service" contracts.

  - As part of this process, the DIB solicits feedback and hosts listening sessions with commercial small UAS companies to gather feedback on addressing the key challenges for "as a service" contracts, including IP, privacy, and contract pricing.
  - The report must include the major challenges facing "as a service" contracts that need to be addressed by either the DoD or Congress (or both) in order for "as a service" contracts to be successfully applied to more innovative technologies.

- DAU designs a new course for applying the "as a service" model to small UAS capabilities for better process training for acquisition officials.

Criteria Evaluation:

- It is a faster and cheaper solution than more traditional procurement pathways, and will be particularly impactful for Combatant Commands who have more urgent operational demands.
- As a consumption-based solution, Operations & Maintenance dollars can be used to buy ISR data from small UAS companies, as opposed to looking for procurement dollars to transition and fully acquire the hardware capabilities.
- Provides a way for the engineers and developers to be in the loop with the end user and warfighter for software updates.
- Software as a service is a well-known and familiar acquisition model in both the DoD and commercial sectors, making training the acquisition workforce more straightforward.
- Allows the DoD to legally accept innovations and critical updates to small UAS software without needing an additional requirement or recompete.

Key Implementation Challenges:

- **Intellectual Property (IP):** IP is a challenging existing debate in the autonomous capabilities space. The same challenge arises here over who would own the IP created or gathered by small UAS capabilities.
- **Labor Rates:** As there are so many components of both the software and hardware development, the regulations are unclear about labor rates, the number of people performing the service, and other labor protection laws for "as a service" or consumption-based contracts.
- **Contract Pricing**: While cloud "as a service" is easy for contracting officers to buy and price, software-enabled hardware "as a service" would be an entirely new skillset within the "as a service" model.
- **Congress**: To scale "autonomy as a service" to a meaningful degree, Congress would need to be comfortable providing more flexible authorities.

Recommendation 3: Strengthen the Domestic Small UAS Industrial Base

> "The war in Ukraine highlights the criticality of a vibrant Defense Industrial Base for the United States and its allies and partners. As emerging technologies transform warfare and pose novel threats to the United States and our allies and partners, we are investing in a range of advanced technologies."
>
> – U.S. National Security Strategy, 2022 [137]

Addresses Challenges:		
Requirements	**Culture**	**Metrics**
Transition	**Budget**	**Workforce**

Meaningful scaling of small UAS capabilities is not possible without a robust industrial base in the United States. The DoD must increase investments in the domestic small UAS industrial base to sustain innovative companies manufacturing small UAS capabilities and take market share back from China in the small UAS commercial market. Warfighters need small UAS capabilities, but many of the start-ups that manufacture some of the most cutting-edge capabilities don't have the supply chain to scale rapidly if they can make it through the full contract and program process.[138] The DoD must be an enabler and better support the expansion of a domestic addressable market for small UAS capabilities.[139] In addition to supporting a strong domestic supply chain, working with allies, partners, and neighbors for near-shoring is also critical for securing supply chains for small UAS manufacturing.

Currently, Chinese companies control over 70% of the global commercial drone market. [140] As countering China remains a mostly bipartisan issue in Congress, China's market share dominance in such a critical, dual-use capability can be leveraged to advocate for an increase in funding and authority from Congress to support American small UAS companies.

Recommended Action Items:

- Institutionalize and expand the DIU's Blue UAS program by appointing an Executive Agent or placing the program within the Army's Aviation PEO, which is currently the largest consumer of drones across the Services.[141]
- Request Congress revisit the GSA SBIR statute that prevents companies with more than 50% backing by VCs or capital market players from competing for SBIRs, as many small UAS companies are commercial-use first and, as a result, have taken considerable VC funding.[142]
- Direct DIU and other DoD innovation entities work with non-profit organizations like In-Q-Tel and America's Frontier Fund to better coordinate on identifying and funding start-up companies in the small-UAS space that are developing unique capabilities.
- Increase civilian billets to the Defense Innovation Unit to expand their engagement teams to connect with nontraditional companies, VCs, and PE firms in the dual-use, small UAS space.
- Task the new Office of Strategic Capital to establish a small UAS portfolio, including the following:
    - Work with the DIU to identify the top U.S. start-ups that can fill capability gaps, but need funding to carry them through the contracting process.
    - Establish stronger connectivity with the key firms in the VC or PE ecosystems who are investing in small UAS companies, and identify funding holes that can be filled through OSC's new mandate and funding.
- Request Congress fund or increase funding to the DoD's Rapid Innovation Fund in the next NDAA, including a specific portfolio or commitment to invest in small businesses in the dual-use, small UAS capability space.
- In response to Congress's NDAA FY23 request to analyze the "national security implications of swarming technologies," propose the following increases in funding:

    - Allocation of $30MM in the next RDER Fund specifically for U.S. companies specializing in AI drone swarming capabilities.
    - Approve multi-year procurement authorities specifically for small UAS capabilities to provide better funding visibility and incentives for start-ups working on swarming technologies.
    - Increase National Security Innovation Capital funds by at least $20MM, with specific allocation to early-stage companies that are working on drone-swarming capabilities.

- Request an increased budget appropriation for National Security Innovation Capital Funding ($15MM in FY23) to $75MM, with a dedicated portfolio of $20MM for early-stage small UAS companies.
- Identify opportunities allied engagement on small UAS industry growth and for "friend-shoring" to strengthen supply chains that are critical for the domestic small UAS industry to grow, including:
    - OUSD Policy (Force Development & Emerging Capabilities Office) to identify opportunities within the AUKUS alliance and other relevant areas for small UAS development and expansion
    - DIU (International Engagement team) to identify international small UAS companies for possible partnerships
    - Establish an interagency task force (including but not limited to DoD, Commerce, and State) to meet with small UAS companies and gather recommendations for strengthening supply chains.

Criteria Evaluation:

- Small UAS companies are eager to work with the DoD, so prioritizing and implementing additional spending authorities and flexible funding will be well received by the commercial sector.[143]
- There is no shortage of existing pathways, programs, and authorities for the DoD to leverage and expand to support the domestic small UAS industry. The DoD will be more impactful in supporting the domestic small UAS industry by supplementing and supporting existing efforts, as opposed to

starting new and possibly duplicative initiatives that may already exist in the private sector.

- Allied engagement is essential for both strengthening supply chains to support both domestic small UAS companies and diversifying the global small UAS industry. The U.S. can leverage its strong network of alliances as a key advantage over China.

Key Implementation Challenges:

- **Funding:** Even with increases from Congress, funding for non-traditional and start-up companies still remains a tiny fraction of the DoD's overall budget. While SBIRs are an incredibly broad and expansion source of funding, the commercialization and transition rates are often in the single digits and not enough to sustain smaller companies over the "valley of death."
- **Communication:** Even with innovation organizations and hubs like the DIU, the commercial sector, and the DoD still speak different languages. Overcoming these language barriers on both sides of the "valley" will take time and effort.
- **Metrics:** Innovation organizations and acquisition entities across the DoD have different metrics for what successful spending looks like, which adds competing priorities and can lead to further dilution of funding instead of strategic prioritization.

Authors Note: The original version of this report, submitted to the Kennedy School MPP Program on April 4th, 2023, included the recommendation for the Secretary of Defense to elevate the DIU to report to the Secretary or Deputy Secretary of Defense to support its expansion and signal the DoD's prioritization of innovation and commercial engagement.[144] *On April 4th, 2023, Secretary Austin announced that the DIU would report directly to the Secretary of Defense and also appointed Doug Beck as the new Director and senior advisor to the Secretary on technology innovation, competition, and strategic impact.*[145]

Recommendation 4: Improve Acquisition Workforce Development and Innovation Connectivity

Addresses Challenges:		
Requirements	Culture	Metrics
Transition	Budget	Workforce

In order to more rapidly field and scale small UAS capabilities, the DoD needs to build trust, improve information exchange, and facilitate more networks between traditional contracting officers, PMs, and defense innovation organizations. Improving transition rates for commercial capabilities like small UAS depends on connectivity between programs of record and defense innovation entities that bring in commercial capabilities.

Acquisition Workforce Development – Recommended Action Items:

- USD(A&S) works with PEOs, the Defense Innovation Unit, and Service innovation organizations to create a new fellowship for contracting officers and PMs to cycle into a temporary placement within an innovation organization.
    - Fellowship or placement includes additional training resources on flexible authorities like MTA and OTA supported by the Defense Acquisition University (DAU) and other industry groups.
    - Create pathways based on capability, including a specific small UAS fellowship, to rotate acquisition officials between the DIU, PEO Aviation, and other small UAS innovation offices.
    - Mandate that participants in the fellowship are eligible for faster promotion or compensation upon completion of their placement.
    - Establish biannual or quarterly meetings or conferences for fellowship "Alumni" to re-connect and continue to build a network as fellows "graduate."

- Introduce a new career track for acquisition officials that focuses specifically on managing contracts for commercially driven and dual-use capabilities.
    - Create new metrics for success and promotion that focus on delivering at speed and emphasizing a "fail fast" approach, as opposed to the more traditional, risk-averse, and linear approach to acquisition.
    - Develop a new training course and pathway with DAU, that focuses on acquiring cutting-edge capabilities and emerging technology.
    - Career track works closely with the DIU and other innovation organizations on training and specialization.
- USD(R&E) works with PEOs and SAEs to establish regular visits to key innovation or service labs and facilitate networking opportunity engagements to connect the research and acquisition workforces and facilitate professional development and training opportunities.
- Increase strategic communication from the Secretary and Deputy Secretary about new capabilities and innovation programs to the broader acquisition workforce.

In addition to building more connectivity between the traditional acquisition workforce and the innovation community, the DoD must significantly invest in preparing the current and future acquisition workforce, both civilian and military, for a rapidly changing technology landscape. As with many modern, dual-use technologies, small UAS capabilities fall in both software and hardware categories, which adds additional challenges for the acquisition workforce to build contracts and programs for scaling.

Innovation Connectivity & Alignment – Recommended Action Items:

- Create "Innovation Billets," similar to the Defense Digital Service, that would place high-performing, entrepreneurial servicemembers or civilian acquisition officials into innovation hubs to lead specific programs to field and scale small UAS capabilities, similar to a Task Force 59 initiative.

- OUSD(R&E) and Service PEOs coordinate with commercial companies like Anduril to fund "Train the Trainer" programs that certify servicemembers to prototype and train others in using small UAS capabilities.
- Create a "Small UAS Acquisition Guidebook," similar to the guidebook released by the Department of the Airforce for AI acquisition in 2022 and led by Service PEOs in coordination with a university or innovation organization. [146]
    - Launch the report with a broad strategic communication initiative about different small UAS programs that have been successfully funded and advanced prototypes that still need to be transitioned.
- OUSD(A&S) and OUSD(R&E) collaborate through existing innovation groups like the DIB or ISG to facilitate a survey of PEOs on their connectivity to innovation hubs to identify major disconnects.
    - Organize the survey based on capabilities (including small UAS) to identify if there are certain technologies that have more or less connectivity.
    - Present findings of the survey to the Secretary and Deputy Secretary and deliver a report to Congress with plans on how to further integrate the DoD's innovation ecosystem.

Criteria Evaluation:

- Building more connective tissue is critical for creating strong formal and informal networks that PMs can use to find funding for technology transitions within innovation organizations across the Defense Department.
- Facilitating better relationships with the DIU and other innovation hub's "internal customers" who have deep knowledge of traditional funding authorities to transition small UAS technologies is critical for more rapid scaling.

- The DoD's acquisition workforce is burdened with a huge amount of regulatory restrictions and legal complexity, so consolidating best practices for scaling small UAS capabilities is important for encouraging more rapid and effective scaling.
- New career tracks and fellowship opportunities for the acquisition workforce are a critical first step to shifting the acquisition workforce culture away from its current risk-averse model.

Key Implementation Challenges:

- **Capacity**: The acquisition workforce is already significantly overloaded with regulatory trainings and compliance, given the complexity of the field. Adding more training without reforming existing processes may not be feasible.
- **Funding**: Additional training or billets would require more money from Congress or would need to come from an existing program.
- **Timeline**: Developing a training program with the DAU for an entirely new acquisition career pathway is a longer-term solution, given the regulatory requirements and needed curriculum development.
- **Culture:** Even with new incentives, professional development opportunities, and career opportunities, cultural change is incredibly difficult and will take significant effort and commitment from senior leadership and Congress.
- **Authorities:** Similar to the funding challenge, identifying the authorities to implement many of these new pathways will be a challenge for OSD and senior leadership.

Recommendation 5: Prioritize Rapid User Feedback

Addresses Challenges:		
Requirements	Culture	Metrics
Transition	Budget	Workforce

Facilitating live user feedback is critical for rapid scaling of dual-use capabilities and avoiding drawn-out prototyping, particularly for small UAS capabilities. First, it trains the end-users (warfighters) on the capabilities and functionalities of the new capabilities, thereby increasing operational readiness. This, in turn, provides essential feedback and opens up development opportunities for commercial companies looking to refine and improve their products for the defense customer base. Second, it significantly shortens the communication cycles between commercial developers and end-users during the prototyping and testing phases, enhancing the iterative design process and leading to more effective and "DoD-friendly" systems. This streamlined communication is particularly vital for the primarily commercial small UAS companies that do not have prior experience working with the Defense Department.

Creating opportunities for small UAS companies to directly experience and understand the battlefield applications for their technologies is crucial. This exposure enables non-traditional companies unfamiliar with defense requirements to more successfully tailor their products to meet the specific needs of the warfighter. In doing so, the cycle from prototyping to deployment is expedited, reducing the time and resources spent on prolonged prototyping exercises and thereby promoting more rapid scaling and integration into existing processes.

For example, AFWERX Autonomy Prime has sought to address this challenge by creating a "proving ground" for early-stage start-ups to test, validate, and train their autonomous capabilities in controlled but realistic conditions.[147] Task Force 59 (TF59) goes a step further by facilitating in-theatre testing for advanced UAS/UUV capabilities, allowing for real-world user feedback in active operational environments.[148] Both of these initiatives serve as valuable models that can be replicated or adapted by other Combatant Commands or services to better facilitate rapid user feedback and technological adaptation. These models inform

the following recommendations for prioritizing and developing more rapid user feedback in the technology scaling process.

Recommended Action Items:

- Provide flexible funding through RDER or APFIT vehicles for Combatant Command to organize "Fly-offs" to evaluate, test, and procure small UAS capabilities. Winners of the "Fly-offs" are prioritized for transitions into programs or purchasing through more flexible funding authorities.
    - Work with DIU, OSC, and service "-werx" organizations to identify a range of companies, from early-stage to more mature, for participation to allow for broader exposure and experience.
- Establish a "bridge fund" for early-stage, capital-constrained companies that successfully participate in "Fly-offs" or other rapid prototyping or in-theater testing exercises. This fund will provide interim funding for further testing while companies wait (known as the "valley of death") for a final program or contracting approval.
- Task OUSD(R&E) Innovation Working Group to identify opportunities to replicate Task Force 59-type programs for other Combatant Commands to field commercial technologies and foster better engagement for CoComms in the technology acquisition process.
- Prioritize Combatant Commands for prototyping exercises, given the more urgent operational need and unique opportunity for in-theater testing.

Criteria Evaluation:

- Overcomes the "valley of death" between fielding tests and commercial small UAS companies. In traditional prototyping exercises, feedback to the commercial company gets "lost in the bureaucratic shuffle" given poor communication challenges and ultimately delays the scaling of critical technology.[149]
- "Fly-off" models that include a wide range of companies – from early-stage to more mature players – provide an opportunity for more unorthodox or

innovative companies to showcase their capabilities and lower barriers to entry.

- Autonomous technologies benefit immensely from in-theatre and realistic environments for demonstrations and development.[150] Prioritizing live feedback allows for small UAS capabilities to become more intelligent and effective for service member use.
- More rapid user feedback supports the paradigm shift to more effectively identifying problems and solutions instead of writing requirements to pre-supposed solutions, when commercial technology is already far more advanced.

Key Implementation Challenges:

- **Transition**: There needs to be a clear "light at the end of the tunnel" for the companies that participate in more direct in-field testing (i.e., "Fly-offs"). If there isn't transition funding attached, the initiatives remain in the same cycle of endless prototyping exercises. CoComms have a very limited (if any) budget for procurement, so funding needs to be allocated from OSD or other services.[151]
- **Innovation Theater:** Introducing or advocating for more prototyping and training exercises for commercial companies can lead to innovation fatigue and more theater instead of deliverables to the warfighter.
- **Funding:** Identifying funding and relevant authorities to manage and facilitate new programs like "Fly-offs" or replication of programs like Task Force 59 will be challenging, particularly for CoComms that have little to no acquisition or research and development budget.[152]

VII. Conclusion

> "Technology is a critical part of everything we do, and it's critical to addressing every strategic challenge facing us today. And that's why DIUx matters. It has to do with our protection and our security — creating a world where our fellow citizens can go to school, dream their dreams, live their lives, and one day give their children a better future."
>
> – Former Secretary of Defense, Ash Carter, 2016[153]

When Former Secretary of Defense Ash Carter founded the Defense Innovation Unit (DIU) in 2015, he recognized the critical importance of leveraging cutting-edge and innovative technologies to advance U.S. military capabilities and strengthen national security. As the threat matrix facing the U.S. grows more complex, Secretary Carter's life-long mission to drive innovation and technological advantage for the U.S. has become even more salient.

This report is built on the conviction that the Defense Department must embrace and invest in critical technologies to strengthen U.S. national security and maintain a rules-based international order. Small UAS capabilities are just one component of a much broader technological landscape that the DoD must harness to prepare for the future fight and a new era of great power competition.

Strategic Relevance for U.S. Policymakers

Given the rapidly evolving geopolitical and threat landscape, the DoD faces unprecedented challenges in maintaining strategic and technological superiority. Addressing these challenges requires an unequivocal commitment to innovation, particularly for capabilities like small UAS, which will shape modern warfare. The analyses and recommendations in this report for rapidly scaling small UAS capabilities have important strategic relevance for U.S. policymakers and leaders.

- **Great Power Competition and Deterrence**: Small UAS capabilities are critical for deterrence and integrating commercial technology and methodologies into the DoD to enable a modern and agile force that is prepared for great power conflict. China is rapidly investing in autonomous technologies, and its military-civil fusion has given it a distinct advantage

in expanding its small UAS fleet. However, the U.S. still has the most robust and advanced commercial innovation ecosystem that the DoD must leverage for advancing military capabilities and deterring adversaries.

- **JACD2 Implementation**: One of the Defense Department's top priorities is ensuring the U.S. military's ability to regain and maintain information and decision advantage against our adversaries or in a contested environment. The Joint All-Domain Command and Control (JADC2) strategy describes the urgent need for the DoD to empower Commanders across the Joint Force to secure command and control (C2) capabilities across all warfighting domains. The three guiding C2 functions are 'sense,' 'make sense,' and 'act.' Small UAS capabilities are critical for all three of these functions and will provide the Joint Force with the ability to gain and maintain information and decision advantage against global adversaries.[154]
- **Evolving Threat Landscape:** The findings in this report show that the DoD is still mainly operating on a 20th-century threat model. With budgeting processes that take up to three years and a culture that disincentivizes productive risk-taking, the Defense Department is not prepared with the needed technological capabilities for a rapidly changing threat landscape. In the ongoing war in Ukraine, small commercial UAS have showcased their operational importance and provided Ukrainian forces with critical ISR and kinetic advantages. As a result of small UAS capabilities, Ukrainian commanders have greater situational awareness, improved sensor-to-shooter capabilities, and faster maneuvering in complex environments. In this era of great power competition, future battlefields are likely to model this highly-contested environment.

Research Applications to Other Advanced Capabilities

The insights and recommendations proposed in this report can be applied to scaling other critical technologies for the DoD. While the focus of this report has been on dual-use, small UAS capabilities, the following technologies stand out as especially relevant for broader application. By considering the recommendations in this report, the DoD can ensure that it stays ahead of the curve in a rapidly evolving threat landscape.

- **Autonomous Technologies**: This report identified key challenges and proposed recommendations for how the DoD can achieve more agility in adopting, integrating, and scaling small UAS technology. However, these findings and recommendations also apply to many other emerging capabilities that the DoD is attempting to scale for military use. This report focused on small UAS with advanced autonomous capabilities so the findings and recommendations could be more applicable to other technologies that also harness and rely on autonomy. For example, many of the challenges facing small UAS contracting pathways also apply to space technology and microelectronics are heavily software enabled.
- **Counter UAS Capabilities:** While this report only focuses on scaling small UAS, many of the same commercial companies are developing cutting-edge autonomous small UAS and also developing important counter UAS capabilities. As a result, the recommendations in this report to build stronger connectivity to the private sector and support the defense industrial base will be important for developing more counter-UAS innovations.
- **Drone Warfare:** This report did not discuss or analyze the scaling of weaponized small UAS capabilities. However, the findings and recommendations in this report would also apply to the DoD's efforts to scale these lethal capabilities.

Areas for Further Research

The findings of this report lay the groundwork for several avenues of further research that could greatly expand our understanding of the role and potential of small UAS in modern defense strategies.

- **High-Intensity Conflict Scenarios:** While this study focused on the importance of small UAS in the context of general great power competition, future research could focus on specific high-intensity conflict scenarios. For example, a detailed war game simulation examining the use of small UAS in a hypothetical conflict between the U.S. and China, particularly in contested regions like the Taiwan Strait, could yield critical insights into their operational effectiveness, limitations, and possible countermeasures.

- **Role of Alliances:** This report touched on the importance of alliances countering China's technology transfer efforts, but further studies should closely examine how alliances like NATO's DIANA and the AUKUS alliance could serve as platforms for cooperative research, development, and scaling of small UAS capabilities, in particular. Investigating the mechanisms and outcomes of such cooperative efforts could provide a roadmap for accelerated innovation and deployment of critical technologies.
- **Integration with Other Technologies:** How do small UAS interact with other emerging technologies such as artificial intelligence, cyber capabilities, and space-based assets? Future research could explore the synergies between small UAS and these technologies to create a more comprehensive and resilient defense ecosystem.
- **Ethical and Legal Considerations:** As autonomous technologies evolve, so do the ethical and legal questions surrounding their use in warfare. Research could further investigate the implications of deploying small UAS in various capacities, such as surveillance or kinetic action, in terms of international law and ethical responsibilities.
- **Supply Chain and Industrial Base:** This report discussed the need for a robust industrial base and how Congress and the DoD can foster its development. Future studies should more deeply explore the challenges and opportunities related to building a resilient supply chain that can support the rapid scaling of small UAS, including analyses of raw material availability, labor skills, and manufacturing capabilities in the United States and near-shore allies.
- **Global Standards and Regulations:** As small UAS capabilities proliferate, there will be an increasing need for global standards and norms governing their use. Research could look into what these standards might look like and how they would impact international security dynamics.

By expanding on these areas, future research can offer a more holistic understanding of the challenges and opportunities presented by small UAS in modern defense contexts.

Ultimately, the imperative for change within the Department of Defense's acquisition and scaling practices for critical technologies like small UAS capabilities has never been more urgent. The United States must respond to the evolving threat landscape with the same resolve and innovation that have historically empowered us to dominate in periods of strategic competition. Thankfully, we are not yet at the point of irreversible technological and strategic lag, but inaction could swiftly tip the scales in favor of adversaries. Crucial steps such as reforming the outdated defense budgeting processes, developing new procurement pathways that rapidly scale innovative and dual-use capabilities, and empowering innovation through the DoD can ensure United States' global leadership. Now is the time for decisive action to ensure that the United States continues to secure global stability and remains at the forefront of technological innovation and leadership for generations to come.

Appendix

Section 1: Key Terms and Definitions

Key Terms

Key Term	Definition
Defense Innovation	The processes of generating, fielding, and scaling technologies and other products, services, processes, or practices that are new or improved in the military context
Defense innovation organization	DoD organizations that were created to help the U.S. military pursue innovative ways to sustain and advance the force capabilities, prototype, and field emerging commercial technologies, and build connectivity with the commercial, dual-use sector
Defense innovation ecosystem	The DoD organizations, activities, pilot programs, functions, processes, hubs, and initiatives that aim to develop, produce, and field new or improved technologies (including purely military, dual-use, or commercial) for military use.
Fast Follower	The DoD's fast-follower approach refers to a strategy in which the Department seeks to quickly adopt and adapt commercial technologies that have already been developed and tested by the private sector. This approach allows the DoD to take advantage of the innovation and expertise of the private sector while avoiding the costs and risks associated with developing new technologies from scratch.
Scaling	Successfully transitioning a small UAS technology to a PM/PEO, operational unit, or other funding mechanism that leads to production, fielding, operations, and maintenance
Small Unmanned Aircraft System	For the purpose of this report, a small UAS is defined as non-lethal, unmanned aircraft system that weighs less than 55 pounds (FAA Regulation weight and DoD weight group 1 and 2)
Transition	A shift in responsibility or ownership of the technology product or system to a PM/PEO, program of record (POR), or an operational unit for production, fielding, operations, maintenance, and/or support activities
Unmanned Aircraft System	DoD defines UAS as powered aircraft that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload.
Valley of death	Waiting period/gap between when a vendor transitions a prototype or commercially available product to a DoD contract, typically one to two years
DoD Definition for AI & Trusted Autonomy	DoD Definition for AI & Trust Autonomy: Artificial Intelligence (AI) is the software engineering discipline of expanding the capabilities of software applications to perform tasks that currently require human intelligence. Machine learning is an engineering subfield of AI that trains software models using example data, simulations, or real-world experiences rather than by direct programming or coding. Autonomy is the engineering discipline that expands robots' abilities to perform tasks while limiting the need for human interaction. AI holds tremendous promise to improve the ability and function of nearly all systems and operations. Trusted AI with trusted autonomous systems are imperative to dominate future conflicts. As AI, machine learning, and autonomous operations continue to mature, the DoD will focus on evidence-based AI-assurance and enabling operational effectiveness.

Defense, Commercial, and Dual-use Technology Frameworks

A major challenge for understanding the barriers to prototyping and scaling critical technology for the military is the varying definitions and categorizations of "critical technology." Without clear definitions, it is challenging to measure success.

Specifically, the term 'dual-use' is arguably no longer fully sufficient to describe the balance between the mainly civilian digital technologies and the more limited military ones that exist today. The term 'dual-use' originated in the early Cold War and was used in particular to describe nuclear technologies which could have both military or weapon and civilian or industrial applications. However, the digital industrialization of the 21st century has blurred the lines between differentiating many digital civilian capabilities from limited military ones.[155]

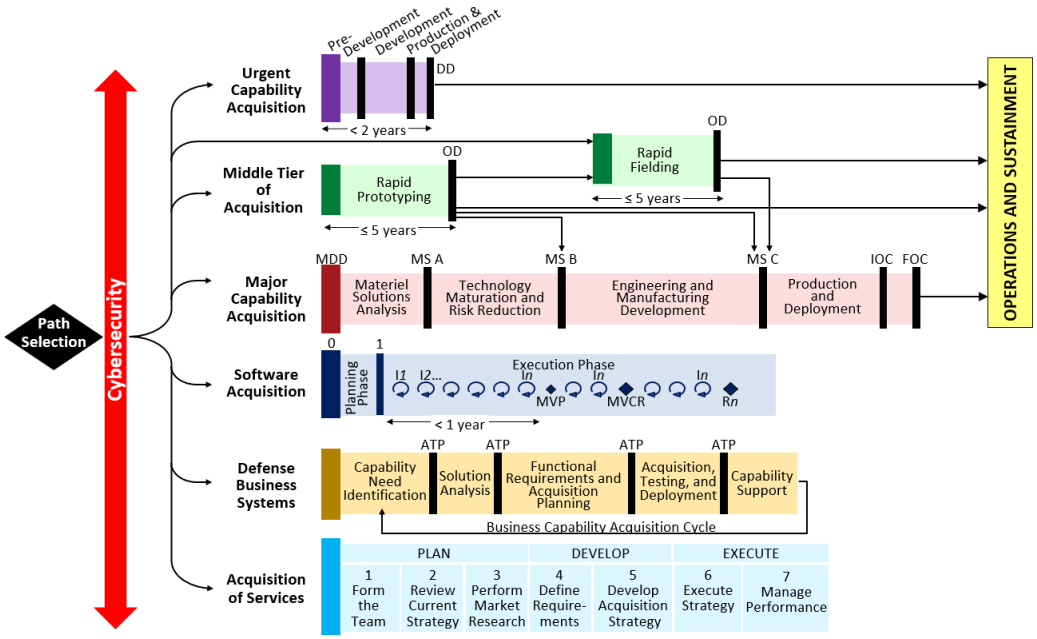
Clarifying "Dual Use" Technology: Jake Chapman, a VC investor in the defense technology space, provides one framework to differentiate between relevant technologies for the DoD.[156]

- *Commercial/Commercial*: Technologies that are developed for the commercial market and remain predominately commercial, also called "commercial off-the-shelf." Best suited to software, support functions, and in many of the back-office processes.
- *Defense/Commercial*: Technologies that originated in defense but have a substantial future commercial market. For example, hypersonic aviation and advanced methods for positioning, navigation, and timing, such as advanced replacements for the Global Positioning System. Not of high interest to VC investors.
- *Defense/Defense:* Technologies that originate in defense and will largely remain focused on the defense market, and the main focus of prime contractors. This category includes innovative munitions, fighters, bombers, ships, and highly specialized applications of certain technologies like AI.
- *Commercial/Defense:* Technologies that are commercial first and defense second. Most commonly referred to by the venture capital community and the U.S. defense community are referred to as "dual-use.

Adaptive Acquisition Pathway Visual

The AAF supports the DAS with the objective of delivering effective, suitable, survivable, sustainable, and affordable solutions to the end user in a timely manner. See the graphic below for the different pathways that have been authorized by Congress to provide more flexible acquisition processes.[157]

Figure 5: Adaptive Acquisition Pathways



Section 2: Images

Cover Page
Image Name: Cover Photo – 7592208
Link: https://www.dvidshub.net/image/7592208/1-8-uas-mortars

Image Description: U.S. Marine Corps Lance Cpl. Donte Mathews, a native of Sykesville, Maryland, and a rifleman with 1st Battalion, 8th Marine Regiment, 2d Marine Division, flys an unmanned aircraft system during a mortar range on Camp Lejeune, North Carolina, Jan. 17, 2023. (U.S. Marine Corps photo by Cpl. Michael Virtue)

Acknowledgements
Image Name: Sec Carter Class

Image Description: Personal Photo taken by Bethan Saunders of Harvard Kennedy School class IGA 282, May 2022

Section II: Mapping the U.S. Defense Innovation Ecosystem:
Image Name: Section II - 7143894
Link: https://www.dvidshub.net/image/7143894/suas-operator-training

Image Description: U.S. Marine Corps Cpl. Joshua Morgan and Sgt. Timothy Rudderham, reconnaissance Marines, 2d Reconnaissance Battalion, 2d Marine Division, operate a SkyDio X2 at Camp Lejeune, North Carolina April 13, 2022. Division Marines attend the small unmanned aircraft system operator course at Training and Logistics Support Activity-East in order to increase the division's sensing and strike capabilities in small teams across various domains. (U.S. Marine Corps photo by Staff Sgt. Akeel Austin)

Section III: Small Unmanned Aircraft Systems (UAS)
Image Name: Section 3 Small UAS - 7501630.jpg
Link: https://www.dvidshub.net/image/7501630/1st-transportation-battalion-conducts-test-and-experimentation-with-navy-operations-and-research-office

Image Description: U.S. Marine Corps Capt. Joshua Grose, left, company commander, and 1st Sgt. Bryan Williams, right, company first sergeant, both with Alpha Company, 1st Transportation Battalion, Combat Logistics Regiment 1, 1st Marine Logistics Group, checks the TRV-150 (TRUAS) drone after landing during Battalion Field exercise 1-23 on Camp Pendleton, California, Oct. 19, 2022. Battalion FX 1-23 is a 1st Transportation Battalion exercise integrated with Project Convergence 22, where Marines and Sailors leverage a series of joint, multi-domain engagements, integrating artificial intelligence, robotics, and autonomy to enhance warfighting capabilities and accelerate decision-making timelines. (U.S. Marine Corps photo by Cpl. Casandra Lamas)

Section IV: Small UAS Case Studies
Image Name: Section IV - Small UAS Case Studies - 7329572
Link: https://www.dvidshub.net/image/7329572/spangdahlem-assesses-paladin-drone

Image Description: Senior Airman Ryan Hospelhorn, 52nd Security Forces Squadron small unmanned aircraft systems program manager, pilots a simulated foreign drone during a Paladin drone overview assessment, July 21, 2022, on Spangdahlem Air Base, Germany. The Paladin drone is being assessed to become another countermeasure for sUAS here at Spangdahlem. (U.S. Air Force photo by Senior Airman Jessica Sanchez-Chen)

Section V: Key Findings
Image Name: Key Findings - 5356116
Link: https://www.dvidshub.net/image/5356116/drone-incoming

Image Description: The 11th Armored Cavalry Regiment and the Threat Systems Management Office operate a swarm of 40 drones to test the rotational units capabilities during the battle of Razish, National Training Center on May 8th, 2019. This exercise was the first of many held at the National Training Center. (U.S. Army Photo by Pv2 James Newsome)

Section VI: Policy Recommendations

Image Name: Section VI - Policy Recommendations - 7132392
Link: https://www.2ndmardiv.marines.mil/Photos/igphoto/2002974150/igsort/PhotoDate/

Image Description: U.S. Marine Corps Lance Cpl. Amadteus Fitzgerald, a native of New Castle, Delaware, and a rifleman with 1st Battalion, 2d Marine Regiment, 2d Marine Division (MARDIV), prepares a Skydio small unmanned aircraft system for flight during Weapons and Tactics Instructor (WTI) course 2-22 at Laguna Army Airfield, Yuma Proving Ground, Arizona, April 4, 2022. WTI is a seven-week training event, hosted by Marine Aviation Weapons and Tactics Squadron One, which emphasizes the development of small task-organized unit experimentation across all warfighting functions, as well as enhance the battalion's ability to conduct command and control, fire-support planning, intelligence functions, and logistical support to distributed company level operations. This exercise continues support of 2d MARDIV's experimental battalion's assessment and mission essential task list-based pre-deployment training progression. (U.S. Marine Corps photo by Pfc. Sarah Pysher)

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