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Investing in Emerging Technologies

Lessons from Unmanned Systems

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It is impossible to separate technology from military power. For thousands of years, the states best able to invent and adopt technologies have found advantages on the battlefield: whether it be the longbow, the *trace italienne*, or the steam engine. However, picking the right technologies and deciding which ones to invest in and how much to allocate for these systems is a complicated set of guesses, a process fraught with uncertainty. This uncertainty is particularly acute when it comes to emerging technologies, in which decision makers must balance educated guesses about the impact of technology with their feasibility—ultimately trading off priorities between known technologies and the promise of future technologies. The states best able to predict the future of technology on the battlefield and make the right investments are ultimately the strategic winners.[1]

Despite the complexity and uncertainty of these decisions, too often, technology is treated as a simple variable; greater investment in technology leads to better outcomes on the battlefield.[2] Therefore, the competition for military power becomes about capacity (in fact, many political scientists use economic capacity and GDP as proxy variables to predict the most capable militaries)—the states that invest in the right technology with the greatest resources generate the greatest military power. And yet, it is often not the case that capacity determines who "wins" the race to master emerging technology or even that greater innovation occurs within the militaries with the largest budgets. Instead, how militaries decide to invest, adopt, and integrate

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military technologies is just as important as any state's inherent capacity to produce military technologies. Therefore, technology is not a simple binary variable but a messy process in which intervening variables, such as human beliefs, organizational preferences, exogenous shocks, and domestic political processes, ultimately determine winners and losers.

Understanding how human interaction with emerging technology influences military effectiveness is pivotal for militaries as they set out to deter and defeat their adversaries. It is also a pressing issue for the US military, facing a daunting peer competitor in China and staring down a revisionist Russia in Ukraine. The Department of Defense (DoD) must make decisions about investments in a series of emerging technologies: cyberspace, offensive space capabilities, hypersonic missiles, artificial intelligence, quantum computing—a growing list of technological buzzwords that vie with one another and traditional platforms for priority within a budget increasingly crowded with competing requirements.

In this piece, I look at one large and heterogeneous group of technologies, unmanned systems, as a case study to glean lessons learned about how the DoD responds to emerging technologies. What lessons might we learn from the decisions made over the last fifty to one hundred years? Are there patterns, or best practices, that may help us better build budgets for today and in the future? Finally, I use these lessons and best practices from a case study of unmanned systems and apply them to current challenges with cybersecurity, space, missiles, and software.

Unmanned Systems—Lessons and Best Practices

Over the last century, the acquisition of unmanned systems reveals a series of lessons about investments in emerging technologies.[3] While capacity and technological development have been important to which technologies ultimately succeeded, these were often secondary factors behind organizational identities, beliefs, policy entrepreneurs, and exogenous shocks to the system.

Masks of War: The Role of Service Identity in Technological Investments

First, perhaps the greatest determinant of when and why some unmanned technologies have succeeded while others have failed is how the technology interacts with organizational incentives: namely, armed service identities. This is not a new phenomenon. Famously, Carl Builder's 1989 study on American military strategy, *The Masks of War*, identifies distinct service-based personalities within each military branch that define their attitudes toward technology.[4] The navy's focus on tradition and independent command at sea leads to decisions prioritizing the navy as an institution. As the only service operating air, sea, and land forces, the navy has the most subcultures and also views itself as the service least reliant on joint escapades, making it the most traditional service institution—focused among all the services.

As the newest command, the air force is insecure about its independence and therefore advocates a doctrine that emphasizes strategic airpower and prioritizes technology over the individual service member. As Builder writes, the air force "sees itself as the embodiment of an idea, a concept of warfare, a strategy made possible and sustained by modern technology. The bond is not an institution but the love of flying machines and flight."[5] In contrast, the army is focused on personnel and has "roots in the citizenry," making it a late adopter of technology and an advocate for personnel-heavy doctrine over the technology-focused efforts of the air force.[6]

Builder focuses on US service culture to explain DoD weapons and doctrine choices but also discusses subcultural identities that derive from operational specialties. For instance, in the air force, fighter pilots once bandied for influence against bomber pilots, and more recently, pilots of unmanned systems have subdivided into a culture distinct from that of other manned fighter and bomber platforms. The navy has an even more codified set of organizational identities than the air force, with three specialties organized as separate personnel and manning structures: surface warfare officers, submariners, and aircrew. Previous work suggests that specialties that face replacement by emerging technologies may be less likely to adopt them and may actively fight back against the proliferation of these systems through budget choices, doctrine development, and personnel choices.[7] However, the strength of these occupational specialties in the ultimate trajectories of emerging technologies is tempered (or magnified) by competition within the service between occupational identities. When an occupational identity is dominant and therefore not in competition, it will be more likely to affect unmanned trajectories—either by its support, its apathy, or its resistance to unmanned systems.

In exploring investments in unmanned systems, service and occupational identities have been the primary predictors for which technologies ultimately succeeded. It required significant external intervention—a war, Congress, or influential policy entrepreneurs—to overcome these identities. When the unmanned system threatened the service's identity, it was more likely to fail. When the unmanned system didn't have an advocate within the service, it was more likely to stagnate. Joint endeavors, often foisted by Congress in a top-down attempt to streamline or consolidate investment, were almost always unable to gain enough support from within services to survive over multiple budget years.

In contrast, technological innovation was spurred when Congress pitted services against one another to develop platforms. In particular, as the newest service, the air force's consummate need to validate its existence meant that when pitted against another service for control over an unmanned system or mission, the air force was willing to adopt the technology even if it countered its core service identity. For example, Theodore von Kármán (a prominent rocket scientist during World War II and colleague of Hap Arnold, the first general of the air force) explained how the air force wrested control over ballistic missiles, explaining, "We used the term 'pilotless aircraft' to cover all types of missiles, so as to prevent the project from falling into the hands of the army."[8] Decades later, the air force's desire to control missions also led it to invest in and adopt remotely piloted aircraft at a far greater level than any of the other services—despite the power of the fighter pilot identity.

While service identities led to different unmanned technology trajectories within each service, in general, it created an incentive across services to focus on manned platforms, which services prized as core to their identity, over unmanned munitions and support equipment like bombs, missiles, communications, or intelligence assets, and finally over unmanned platforms. For example, despite early successes, the torpedo met significant resistance from the capital-ship navy, which viewed the torpedo as a threat to its traditional structures. As Katherine Epstein recounts in her exploration of torpedo development within the United States, "The result was a race for range between guns and torpedoes that raised the possibility that the entire system of tactics built around capital ships armed primarily with big guns would give way to one built around smaller vessels primarily armed with torpedoes."[9] Decades later, the navy continued its resistance to munitions that threatened operational identities, developing cruise missiles as a last resort to fend off ballistic missiles, which were incongruous with their platform of choice—the aircraft carrier. It wasn't until Admiral Hyman G. Rickover, who led the development of nuclear-powered submarines, saw the ballistic missile as a way to preserve and promote the submarine that ballistic missiles were embraced within the navy budget (this also led to the innovation of liquid over solid propellants).

And while the air force's uneasy embrace of ballistic missiles has already been alluded to, the air force also put up a spirited resistance to cruise missiles in the 1970s, concerned that the munitions would decrease the chance that their new bomber, the B-1, would be funded. This resistance continued beyond missiles and into space, where the navigation satellites of the global positioning system were almost cut multiple times as the air force questioned the prioritization of space-based precision over pilot-directed laser-guided bombs. Finally, the army's Future Integrated Combat System—which promised to link together lightly armored vehicles with drones and other support equipment—famously failed in part because the army was more focused on the vehicles of the system and underfunded the network technology required to link the platforms together.

The Power of Narratives, Beliefs, and Policy Entrepreneurs

In many cases, the only reason that unmanned technologies have survived organizational incentives and service identity bias was that they became part of a larger narrative. Narratives about the future of technology and beliefs about how technology might impact the future battlefield have been key to convincing both service chiefs and Congress to preserve investments in technologies that might otherwise have been cut. In particular, two core belief narratives have dominated US defense discussions about technological investment in the last fifty years. The first belief, technological determinism, is that technology exists within a linear understanding of history in which technology punctuates equilibrium to create revolutionary advances in military effectiveness. Unmanned systems are a part of that linear progression as a component of the most recent information technology revolution.[10] According to these beliefs, technology is the primary agent of change. It is, therefore, the responsibility of the United States to harness the power of unmanned technologies to leapfrog adversaries by creating campaigns of speed, situational awareness, and decisive advantage.

The second set of beliefs—derived primarily from the US experience in Vietnam and midgrade officers who dominated US defense thinking post–Cold War—is about casualty aversion and force protection. It holds both that the US public is casualty intolerant and that its opinion is important for the military to achieve strategic success.[11] Public opinion about the loss of troops constrains decision makers and influences the choice of military tools on the battlefield. By removing US personnel from the battlefield, unmanned technologies provide a technological solution to the constraints decision makers believe are imposed by the American public's casualty intolerance. These beliefs interface with identities created by military service and occupation specialties that shape investments in and the adoption of unmanned technologies based on beliefs about how unmanned systems support or threaten service and operational cultures.[12]

Beliefs become more influential to policy when they are championed by an enterprising individual, particularly one with power within the services—for example, the navy's Admiral Rickover pushing for ballistic missile submarines, the air force's General Curtis LeMay advocating for strategic bombers, General Bernard Schriever energizing the air force's ballistic missile development, or the army's General Donn Starry creating the Corps-86 acquisition program to implement AirLand Battle. Occasionally there are individuals outside the services who can build powerful narratives and create networks of influence that circumvent service identity to influence technology investment choices from the outside in—Senator John McCain famously pushed the navy and other services to evaluate their own biases, and President Dwight Eisenhower played an outsize role in shaping the strategic arsenal of the United States after World War II.

These two dominant narratives that drove technological investments post–Cold War involved individuals who had outsize effects on narratives about technological development. The first type of policy entrepreneurs were those officers like former chair of the Joint Chiefs of Staff Colin Powell—junior or midgrade officers during Vietnam—whose lessons learned about public support and casualty aversion shaped doctrine and technologies focused on force protection. These officers, generally from inside the army and to some extent the air force, influenced decisions about technology investments across the services that focused on range, precision, and situational awareness to decrease the risk to American personnel. A second group of policy entrepreneurs, led by the Office of Net Assessment's Andy Marshall, leaned on civilian scholars, policy leaders, and networks of rising military officers to propagate a theory of revolutions in military affairs. This internal group of military leader entrepreneurs, combined with the outside push of civilian policy entrepreneurs, led to sometimes conjoined narratives about technology to protect the force and create overwhelming technological victories. Together, these individuals created the crucial impetus by which beliefs about unmanned technology translated into policy and acquisition choices that could overcome status-quo biases for service identity.[13]

From the Outside In, the Exogenous Push and Pull on Technological Investments

So far, most of these lessons have been learned by looking at defense technology processes from the inside. However, outside catalysts play a key role in shaping the trajectory of technology. Perhaps most unsurprisingly, wars drive innovation. They provide both an impetus and increased funding for technology, serving as immediate proving grounds for technology that might otherwise be favored (or rejected) by services.

This has happened time and time again for unmanned systems. For example, torpedoes—which showed early promise—languished after World War I.[14] Faced with declining defense budgets, the navy moved the systems to the bottom of their priority list, behind the new aircraft, submarines, and carriers the service was clamoring for. When World War II began, the navy was left with "a tiny dribble of beautifully crafted torpedoes, barely less erratic than their World War I forefathers, produced by an organization corpulent, sluggish, and not so much consciously resistant to change as physically and emotionally unable to."[15] Only World War II forced the navy to restart its torpedo development and introduce the far more capable Mark 24 and 28 torpedoes.

Similarly, Vietnam drove tactical unmanned investments like unmanned aircraft and autonomous munitions, which were ignored under the peacetime dominance of the Strategic Air Command. More recently, 9/11 led to the armed remotely piloted aircraft, a phenomenon that has dominated unmanned system investments in the last two decades. As then secretary of the air force James Roche recounted, there was a lot of resistance to arming the Predator before 9/11, but then "two buildings fell over," and suddenly arming the Predator didn't seem nearly as risky or revolutionary as it had previously.[16]

In some cases, it wasn't just war that provided an exogenous shock to technology. While much of the Cold War was dominated by service identity and organizational competition, Sputnik and the nuclear threat created impetuses for investments in emerging technologies that might have otherwise failed. Despite early studies post–World War II into the feasibility of space reconnaissance and even a 1954 RAND report that called for a "satellite reconnaissance vehicle" as a "vital strategic interest to the United States," satellite development remained a low priority for both the air force and the navy until the exogenous Sputnik shock in 1957.[17] At the time, the navy had a Vanguard satellite program in development, but the program had been kept secret and given a tight budget, ostensibly so it wouldn't compete with investments in ballistic missiles.[18] It also didn't help that then secretary of defense Charles Wilson didn't believe in satellites and showed open ambivalence to the Soviet efforts. All that changed when the Soviets launched Sputnik into orbit, which riveted US onlookers and caused the national security community to worry about a missile gap with implications for intelligence and nuclear stability.[19] The Sputnik moment also created a window of opportunity for the air force's General Schriever. After Sputnik, the Atlas missile program and its descendant, the Titan, sprinted forward technologically as congressional and executive branch pushes to respond to the Soviet lead in space ensured a solid budget allocation.[20]

Congress, and to some extent, the executive branch, play important external catalyst (and confining/shaping) roles for technological development. While Congress is often derided for retaining weapons that support industries within their representative districts, it often plays an important role in saving technology that would otherwise not be funded by the services. Congress and various presidential administrations, for example, can be credited for saving most of the ballistic and cruise missile technology that now exists in the US arsenal. It took civilian intervention, first from President Eisenhower's famous Project Solarium and then from senior civilians in air force research and development, to create a new protected entity within the air force focused solely on developing ballistic missiles.[21] Similarly, the air force's resistance to cruise missiles was largely the byproduct of the service's support for the B-1, a low-altitude, high-speed bomber designed to negate the increasing lethality of Soviet surface-to-air missiles and fighter interceptors. But with new missiles that were far more precise, had much greater ranges, and could evade air defense systems sometimes with better success than manned alternatives, the air force struggled to convince Congress or the executive branch that the US needed a new manned bomber.[22] In fact, President Jimmy Carter almost nixed the B-1 entirely, preferring a new "cruise-missile carrier" over the air force's manned bomber proposal.[23]

Congress and the executive branch also play an important role in influencing budget cycles, which serve as critical junctures for technological trajectories. Investments in research and development made in big-budget years create a path dependency for technologies during subsequent lean years. This can lead to suboptimal technological trajectories. Emerging technologies are more likely to be cut by the services during lean budget years, making outside intervention more important to saving technologies that are not otherwise preferred by the services. It also may leave the military with a glut of technology that isn't optimized for the current context. For example, the massive influx of defense spending during the Reagan years led to innovations in precision munitions but drawdowns in unmanned platforms, while post–9/11 conflicts inflated investment in remotely controlled unmanned platforms over long-range missiles or systems that may be useful in conflicts featuring more capable air defense systems (such as with China or even Russia).

Finally, the unmanned case suggests that the defense industrial base rarely innovates alone. There are very few cases of successful technological innovation started by the defense industrial base without a requirement from the Department of Defense. Instead, the tale of unmanned technologies is replete with examples of civilian innovations that fail to find customers within the military until a large exogenous shock forces the military to revisit (and sometimes resurrect) these technologies. This, understandably, decreases incentives for companies to produce technology that is not already explicitly requested by the DoD. The Predator is a rare exception; General Atomics invested in the system largely without a DoD push—a strategy that only succeeded because of the exogenous shock of 9/11.

Conclusion: Implications for Other Technologies

Investment in unmanned systems over time reveals a few lessons about the process of how emerging technology succeeds and fails. First, the status quo for technologies is that they will succeed or fail based on how well they fit into a service's identity. To negate these biases, it is important to have the services compete against one another when necessary. Also, leaning on Congress and the executive branch can exert important top-down pressure when processes stagnate. Narratives, especially those propagated by successful policy entrepreneurs, can help overcome service biases. But perhaps the biggest implication of this research is that a general self-awareness within the DoD of when technologies might inadvertently be set up to fail because they don't have organizations or individuals to spearhead them in the budget process could lead to better acquisition and development processes for emerging technology. There are also more specific implications for other emerging technologies.

First, this study suggests that cyber technologies—especially those developed for defending the nation—will need a champion to ensure their priority within defense budgets. Services are optimized to develop cyber technologies that benefit their core identities, and yet the primary cyber force tasked with defending the nation is the Cyber National Mission Force (CNMF), a joint organization subordinate to a joint functional command, cyber command.[24] Previous lessons from unmanned systems would suggest that carving out a joint organization to spearhead and defend the nation's mission (ransomware, defending elections, combating intellectual property theft, etc.) would be an uphill battle doomed to fail—fighting the services both for top talent to man billets and for control of cyber acquisition budgets. Indeed, for the last decade, the services have dominated this fight, allocating personnel to their missions first while almost all of the cyber acquisition budget passed straight through cyber command to the service cyber elements. Leading up to 2022, cyber command had budget oversight of only $600 million of an overall DoD $40 billion cyber/information technology budget (and even that small percentage was a significant increase from the $75 million cyber command was given authority over in 2018).[25]

But cyber command, led by the charismatic army general Paul Nakasone, has waged a persistent and successful battle to influence legislation to protect the CNMF and cyber command. Cyber command has not only been given authority (starting in 2024) for full budget control of the cyber/IT portfolio, but it has also elevated the CNMF to a subunified command, securing billets and budgets for the joint organization. How has cyber command been able to do this? First, cyber command crafted a narrative about its role, its mission's uniqueness compared to those of the services, and the need for greater authorities and budgets. In an effort colloquially known as persistent engagement, "Cyber Command published its strategic vision before the Trump National Defense Strategy or Defense Cyberspace Strategy."[26] Doing so preempted the cyber narratives in the DoD and NSC strategies and propagated the idea of a more forward-leaning and independent cyber command through academics, editorials, and professional military education.[27] This narrative benefited from the charisma of General Nakasone, who retained command of cyber command and the National Security Agency even while there was a revolving door of cyber leaders within the White House and in the position of secretary of defense. This campaign also benefited from a small pool of cyber leaders, many of whom served under Nakasone or cyber command before rotating to lead service cyber elements. By promoting within the cyber command instead of from more traditional service hierarchies, cyber command retained influence within service cyber elements. Cyber command also began a public-facing effort to advertise previously covert efforts, creating a new Twitter account to disseminate malware in real time, partnering with the (also charismatic) Chris Krebs at the Department of Homeland Security, and serving as a public face for a successful campaign to defend the US elections against Russian and foreign interference. The congressionally mandated Cyberspace Solarium Commission also protected the Cyber National Mission Force, recommending and then spearheading the legislation that ensured the force would remain funded and increasingly protected from the services. Of course, all these factors were helped by the services' relative disinterest in cyber versus more traditional missions, which allowed for cyber command to play a larger role in cyber budgets and control.

Related, and perhaps even more complicated, are investments in information technology and Joint All-Domain Command and Control (JADC2). The information technology structure of the military is already divided into armed service segments (the air force owns its network and data, etc.)—a phenomenon that makes basic information technology (and cybersecurity) upgrades difficult to implement across the DoD information technology network. It also leads the services to make very different decisions about applications, software development, and basic information technology practices. This creates complications for enterprise-wide initiatives through the Defense Information Systems Agency (DISA) and a natural jockeying between DISA and the armed service information technology organizations. It also means that JADC2—an effort to combine these networks to communicate and share data seamlessly across the services—will be extremely difficult to implement. Joint organizations and initiatives are notoriously challenging, and the services' natural inclination to invest in platforms over infrastructure means that the ambitious information technology program faces multiple obstacles. However, lessons from the unmanned case about interservice competition suggest that Congress may incentivize the services to work together or prioritize information technology funding by threatening to allow one service to run the entire JADC2 program. Pitting, for example, the air force's Advanced Battle Management System against the navy's Project Overmatch may create an impetus for innovation where the status quo default is for stagnation.

The introduction of the US Space Force complicates the role of service identity in investments in emerging technology. The power of service identities means there is a natural inclination for armed services, especially one that is new and concerned about its survival in the future, to push for technologies that create a novel role in space. While the space force is still developing its identity, the focus on offensive weaponry, warriors, and armed competition in space could lead to more investments in space-focused missions (e.g., space-based early warning, space weapons, etc.) over investments in intelligence, communications, and support for terrestrial missions. This was a large concern for President Eisenhower, who was apprehensive that service biases would harm space investments and needlessly cause a space race with Russia. To counteract these biases, Eisenhower placed almost all space capabilities under a civilian organization, the National Reconnaissance Office. In the seventy years since, some would argue that Eisenhower's decision has underemphasized space capabilities in the defense budget and that the creation of the space force only corrects this imbalance. Further, by creating an armed service that must compete for resources, the new structure may lead to innovations in processes and personnel that lead to better acquisition and adoption of emerging technologies (as some would argue the marines have exemplified). For space, the challenge will be surviving as an organization separate from the air force without leaning on identity biases that lead to less effective uses of emerging technology.

This research also has implications for the future of US conventional missile capabilities. Why hasn't the United States invested as much into hypersonic missiles as it probably should have? Why does the United States not have a larger, more sophisticated arsenal of conventional strike surface-to-surface (or even ship-to-ship or ship-to-shore) missiles? Part of the reason why the nation has fallen behind states such as North Korea and Iran in conventional strike options, and China in hypersonic missile options, is a product of context and the US-Soviet relationship in particular. Arms control agreements between the United States and the USSR limited much of the conventional strike arsenal; even cruise missiles (which were not explicitly a part of strategic arms control agreements) were used as part of a negotiating tactic for the United States trying to limit nuclear arsenals. Organizational interests also handicapped the US conventional strike development. The army abdicated its stake in long-range missiles completely by the 1980s to the air force, which was happy to commandeer the mission from the army but also was not interested in investing in missiles that didn't fit into the nuclear mission of Strategic Air Command, nor the conventional campaigns fought by Tactical Air Command. Meanwhile, the navy (like the air force) lost interest in conventional strike missions that might threaten the bread-and-butter aircraft of aircraft carriers, while submarines, generally focused on strategic strike missions, were underprioritized as a conventional missile strike option. Even though missiles were a core part of technological narratives coming out of the DoD after the Cold War, these organizational and contextual complications meant that the focus was on missiles as munitions that could be carried by existing platforms like aircraft and destroyers. Even when leaders recognized the need for emerging technologies like hypersonic missiles, there were few service imperatives to invest in systems that didn't fall neatly into organizational niches and threatened the role of favored platforms.

Finally, this work reminds us that technology does not exist without human intervention. We cannot simply invest more in technology and expect it will lead to victory on the battlefield. Instead, how technology shapes the winners and losers in war is a result of the process by which organizations, individuals, and beliefs create and use that technology in the first place. For the US military, what this means for preparing for a future conflict with China or sustaining support to Ukraine against Russia, is that the United States cannot just increase defense budgets and expect that it will assure a technological edge. Instead, the US military must focus as much on reforming the process of developing, acquiring, and implementing new technology as it does on fighting for larger budgets. A large part of this fight will be in reexamining the power of the armed services. It has been decades since the Goldwater-Nichols Act, the last major initiative to temper the role of service identity in defense budgets, and an evaluation of the success of these reforms is past due. Instead of building new services, the DoD should evaluate whether the current structure and power of the current division of services are best for military effectiveness. This will be a tall order that will require a Congress and executive branch willing to make difficult reforms at a time when civil-military relations are already strained. It will require new policy entrepreneurs from within and above the services, able to build compelling narratives for new weapons and concepts of operation.

Hopefully, the United States can do this without the push of war, because it is unclear that, if left to the status quo, the nation will be able to compete or win against an adversary on the level of China. In many of the emerging technologies that now dominate the discussion about future warfare—hypersonics, artificial intelligence, offensive space capabilities—China looks to be an early leader.

Meanwhile, after decades of conflict against terrorists and insurgents, the United States has an inventory of weapons ill-suited for the high-tech, primarily naval and air fighting in the Pacific. Can we reform our processes to regain the technological edge? Can we pivot our technological investments even in the face of economic uncertainty? The United States may only have a short time to answer these questions.

Notes

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