9

A Requiem for Defense Innovation?

Ukraine, the Pentagon's Innovator's Dilemma, and Why the United States Risks Strategic Surprise

Christopher Kirchhoff

In 1989, Apple CEO John Sculley had a vision of the future. He foresaw a convergence of consumer electronics and telecommunications and started a secret group within Apple to explore what this would make possible. It was called the "Paradigm Project," and its mission was to build "a tiny computer, a phone, a very personal object. . . . It must be beautiful. Once you use it, you won't be able to live without it."[1]

When the small team's attempts to bring together the component technologies of the smartphone struggled for resources within a corporate culture at Apple that was pursuing other priorities, Sculley spun the company out, realizing it could only thrive if set apart. The spinout, General Magic, quickly grew to one hundred employees. Working feverishly in the early 1990s and eventually in partnership with Sony, Motorola, Philips, and AT&T, it developed precursors to USB, software modems, touchscreens, multimedia email, networked games, streaming TV, voice recognition–based personal assistants, and e-commerce applications.[2]

General Magic came tantalizingly close to realizing the vision for a tiny computer phone. Ultimately, its technology fell short of the advances needed for a consumer device. It would be another decade before Apple productized General Magic's innovations in the 2007 release of the iPhone, which brought the power of computing and the reach of the internet into the palms

The views expressed in this chapter are solely those of the individual author and do not necessarily reflect the views of any organization with which they are, or have been, affiliated.

of our hands. Apple's iPhone became the fastest proliferating device in human history, revolutionizing how we live and work and laying the foundation for future industries, including today's "Internet of Things," which comprises 31 billion devices worldwide.

What does this story tell us about our world? The interplay between radical visions, motivated teams working outside of corporate strictures, and the struggle to bring innovation back into settled organizations is a common motif in the history of technology. The very structure of market capitalism and large institutions makes for a dynamic in which stunning advances often occur outside places where they can easily be scaled. This gives innovation its "fits and starts" character, with surprising gaps frequently emerging between the invention of technology and when it becomes widely available. Looking at the same phenomenon through a business lens, the late Harvard Business School professor Clayton Christensen described "the innovator's dilemma" faced by successful corporations that fail to pivot to the technologies that will prevail tomorrow.[3]

Seven years after Secretary of Defense Ash Carter spun out Defense Innovation Unit Experimental (DIUx) and launched the Defense Innovation Board (DIB) and the Defense Digital Service (DDS), it's time to ask whether this motif is playing out inside the Pentagon as well. These initiatives and other innovation cells inspired by them in each military service, like the Algorithmic Warfare Cross-Functional Team that launched Project Maven, have achieved stunning successes in both deployable technology and the methods used to develop and procure it. Yet despite notable progress in specific areas and on small scales, they have not meaningfully transformed how the Pentagon adopts emerging technologies or procures large systems for the future of war.

Like their fellow travelers at General Magic, who watched as Apple remained unmoved by the promise of an integrated smartphone, the innovators Carter unleashed in 2015 see the kind of war they imagined in 2016 and 2017 playing out today on the European steppe. Ukrainian command and control are substantially enabled by modern digital technology like smartphones, secure messaging apps, and Starlink. Significant intelligence, surveillance, and reconnaissance come from commercial satellites and social media apps that enable real-time citizen reporting of Russian positions. Commanders direct strikes using commercial drones. Perhaps most strikingly, commercial technologies are being deployed by both Russia and Ukraine in tandem with exquisite weapons systems to enhance their effectiveness and better enable their defeat. One of the most significant lessons to emerge from Ukraine

may be the difference commercial technology makes in a great-power conflict, especially its ability to attrit superior enemy weapons systems, supplant legacy command, control, intelligence, and reconnaissance, and multiply the combat effectiveness of stock armaments from Ukraine, Russia, NATO, and the United States.

Yet eight months into a real-life demonstration of the hypothesis that led Ash Carter to launch his innovation initiatives, Pentagon acquisition chief Bill LaPlante—the man most responsible for future US armaments—said this:

> We're not fighting in Ukraine with Silicon Valley right now, even though they're going to try to take credit for it. The tech bros aren't helping us too much in Ukraine. . . . It's hardcore production of really serious weaponry. . . . That's what matters. . . . If somebody gives you a really cool liquored-up story about a DIU project or OTA contract, ask them when it's going into production. Ask them how many numbers, ask them what the unit cost is going to be, ask them how it will work against China. . . . Ask them all those questions because that's what matters. And don't tell me it's got AI and quantum in it. I don't care.[4]

LaPlante's sentiment that commercial technology is not a significant driver of battlefield outcomes in Ukraine and has few use cases against the Department of Defense (DoD) keeping pace with adversaries, while met with fierce criticism, is to a significant degree reflected in where dollars and leadership attention are spent.[5] Despite having the highest conversion rate to the production of any DoD entity, including the Defense Advanced Research Projects Agency (DARPA), DIUx's budget has flatlined after two successive under secretaries of research and engineering, the first of whom served under Trump and the other under Biden. Both chose not to support its growth. The sitting secretary of the air force just scaled back AFWERX, the service's commercial technology incubator, influencing the retirement of its director. Even as the commercial sector leads in eleven of the fourteen critical technology areas identified by the Pentagon's under secretary of defense for research and engineering, Heidi Shyu, her own office, which administers a new fund to transition emerging technologies expeditiously, recently made only one of ten awards to a venture-backed business.[6] While these outcomes are not the full story, they are certainly not what was hoped for by Ash Carter when he nudged the department toward embracing the fruits of the $25 trillion commercial technology market.

This paper traces efforts at defense innovation across three presidential administrations—those of Barack Obama, Donald Trump, and Joe Biden. It highlights significant successes but notes substantial stasis across existing initiatives. It explores whether, in light of Ukraine and parallel developments in other battlespaces, especially China, the stalling of the innovation agenda may spell a future strategic surprise for the United States.[7] The Pentagon's innovator's dilemma in this way may be an ordinary and expected outcome in the struggle for disruptive change in one of the world's largest institutions, while at the same time—because of the rapidly changing landscape—a strategic crisis for the United States.

Defense Innovation's First Wave: The Obama Years

Ash Carter's great insight into the future came in 2001. America's twenty-fifth secretary of defense, then a Harvard professor, wrote of a looming challenge to the military's technological edge. This challenge emerged not from an external threat but from "trends in the industrial and technology base." A decade after the end of the Cold War, advanced technology, "once largely the creation of the Department of Defense," he noted, is "increasingly becoming commercialized and globalized. Tomorrow's defense innovations will largely be derivatives of technology developed and marketed by commercial companies for commercial motives." To keep its edge, Carter concluded, the military "must be the world's fastest adapter and adopter of commercial technology into defense systems."[8]

Carter was sworn in as secretary at a time when the world was awash in the newly powerful technology he foresaw. The global consumer market was by now orders of magnitude larger than the Pentagon's acquisition and R&D budgets (see fig. 9.1). In less than a generation, the locus of innovation moved from defense labs to tech companies, many of them global, with some of the most important located in China. By 2015, Google and Apple were each larger by market capitalization than the US defense industry. Apple had, then, and has today, enough cash to buy all prime defense contractors outright. The result of this shift is seen in the hardware the military uses today. All but 4 percent of the components in one of the US military's most advanced electronic warfare systems—the Aegis-class destroyer—are commercially available.

This diffusion of military power, unprecedented in speed and scale, touched off an innovation race among advanced militaries. Carter moved to better position the United States for it by launching three initiatives, creating (1) an innovation board of luminaries to provide a vision for the department;

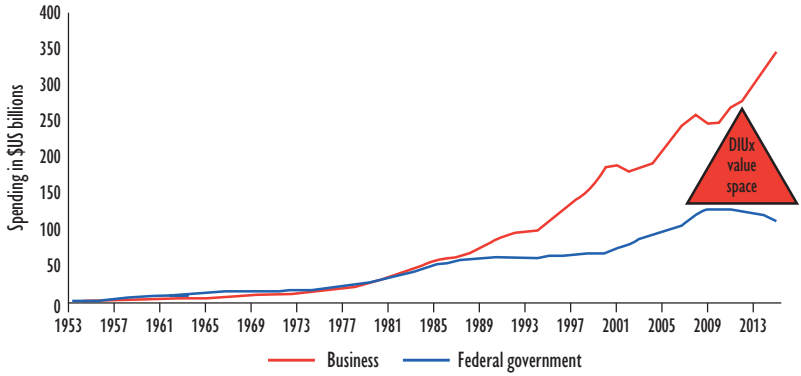

Figure 9.1 Commercial versus Federal Government R&D Expenditures, 1953–2013

The private sector outspends the federal government in R&D spending by a ratio of more than three to one.

Source: Defense Innovation Unit Experimental (DIUx), 2016.

(2) DDS, a software factory; and (3) DIUx, a new embassy of sorts in Silicon Valley. Specifically, DIUx was created to pilot commercial technologies in military missions and went on to open offices in the tech hubs of Boston, Austin, and later Chicago.

Momentum for using off-the-shelf technology and hardware and software from start-ups had been building. Special Operations Command's SOFWERX, the US Navy, US Cyber Command, and the National Geospatial-Intelligence Agency were already engaging the Valley differently in the 2010s. Small delegations from each arrived to find In-Q-Tel already there. Since its inception in 1999, the intelligence community's strategic investment firm has made three hundred twenty-five investments to advance the intel mission.[9] Multiple DARPA offices also had long sought R&D breakthroughs from start-ups and continued to engage them. Importantly, though, DARPA's mission to prevent and create strategic surprises through bold technical leaps was distinct from what Carter envisioned for DIUx, which focuses on adapting fully developed commercial technology for use on the battlefield.[10]

To a significant degree, Carter launched these initiatives out of desperation. In the view of Chris Brose, former staff director of the Senate Armed Services Committee, the second decade of the twenty-first century was one of colossal missed opportunities for the US military. DoD, on the whole, had missed the advent of modern software development, the move to cloud computing, the commercial space revolution, the centrality of data, and the rise

of artificial intelligence (AI) and machine learning. This was the case despite having funded the fundamental research that led to many of these advances.[11] DIUx and DDS were to change this by placing DoD personnel directly in the commercial technology ecosystem.

DIUx was announced at Stanford University by Carter during the first visit to Silicon Valley by a secretary of defense in a generation.[12] When its first iteration failed to take root, Carter doubled down, announcing what he called "DIUx 2.0." With its additional features, the new release included a direct report to him and the capability to rapidly contract, which version 1.0 lacked.

DIUx 2.0 proved the validity of its model almost immediately. It funded $250 million in pilot technology projects in its first eighteen months. DIUx also pioneered a novel use of Other Transaction Authority (OTA), a little-used acquisition pathway developed in 1958 to meet NASA's need to contract quickly with small businesses during the space race. The specific OTA contract DIUx developed in 2016, called a Commercial Solutions Opening (CSO), could be closed in under a month and allowed for the immediate conversion of successful pilots into production—available to be bought by any customer across the DoD—without further negotiation. This contracting superpower was enabled by new authorities granted by Congress that no one in the department had bothered to use. DIUx exported this contracting innovation via a "how-to" manual so other entities across the department could run the same play. It also got Carter, in four weeks' time, to bless it as a DoD-wide policy. By 2022, this small revolution in procurement was used to acquire $39 billion of commercial technology for the DoD.[13]

DIUx's early projects mirrored General Magic's experimentation with the component technologies of the future. They included microsatellites using low-cost synthetic aperture radar (SAR) sensors to pinpoint enemy weapons, AI-powered drones, robotic boats that provide surface effects at fractions of the cost of a destroyer, cloud computing infrastructure with native machine-learning capabilities, and even flying cars and autonomous undersea vehicles.[14]

While not every project was a success, and not every company DIUx worked with is still in business today, its early track record was promising. Among DIUx's initial wins: finding a low-cost way to deliver on-orbit SAR capability against a top-five military intelligence priority and developing an app that optimized mission planning for fifteen-hundred daily tanker refuelings during the air war against ISIS. With its tanker refueling app, DIUx did for the air force in one hundred thirty-two days and for $1.5 million what a

ten-year, $750 million program of record had not. The chief of staff of the air force was sufficiently impressed by DIUx's handiwork that he moved to create Kessel Run, the air force's software factory, which now employs 1,200 people, and named the project manager of the tanker app to lead it.[15]

Crucially, early rounds of DIUx contracts helped catalyze a new trend of venture funding for start-ups that explicitly target the defense market, with the round Andreessen Horowitz led for Capella Space at DIUx's instigation being something of a shot heard 'round the Valley. Traditional defense contractors also shifted into innovation gear, with Boeing's HorizonX, Lockheed Martin Ventures, and Airbus Ventures becoming investors in the Valley ecosystem.

The DIB and DDS bolted out of the starting blocks as well. Filled with technology luminaries, the DIB's members traveled with the leaders of DDS and DIUx to dozens of installations in the United States and overseas, meeting with commanders and rank-and-file operators.[16] They transformed insights from hundreds of hours of observation into landmark reports that established a framework for the software revolution that swept the department, the adoption of AI, how to grapple with 5G, and how to manage talent more effectively. They also established a set of principles for the ethical use of AI in war.[17] DDS quickly created the federal government's first-ever bug bounty program, memorably titled "Hack the Pentagon," which was open to coders in all countries except Iran, North Korea, and China. DDS also created a new compliance framework to more rapidly get new software up and running and dispatched its "SWAT team" of coders and data scientists to all corners of the department.[18]

By the time Ash Carter left office on January 20, 2017, his three vehicles for commercial innovation—DIB, DDS, and DIUx—were not even two years into their operational missions. Yet each made its mark, producing local success with global lessons for how DoD could import powerful technologies honed in commercial markets. By themselves, these vehicles were not designed to be of the scale or heft to foundationally alter department practices. The three entities had little more than a hundred people and a combined budget of less than $100 million. Yet they succeeded on the terms Ash Carter set by proving the model of innovation they were predicated on and by inspiring others to follow in their wake. To borrow a phrase from Mao Zedong that Carter would chuckle at were he still with us, his actions let a thousand flowers bloom, particularly as commands in each service set up their own miniature DIUxs and DDSs (see fig. 9.2). It would be up to his successors to build on this momentum.

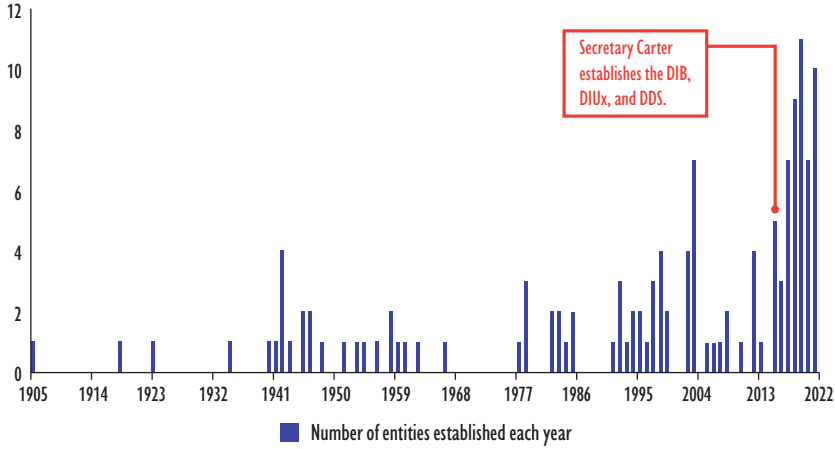

Figure 9.2 Historical Pace of Innovation in the US Armed Forces

Sources: Eric Schmidt, "Remembering Ash Carter: The Innovative Secretary of Defense Who Changed the Pentagon, Silicon Valley, and the Trajectory of Our Nation," Special Competitive Studies Project, January 26, 2023; data drawn in part from Under Secretary of Defense for Research and Engineering, "Innovation Organizations."

Innovation under the Trump Administration

The election of Donald J. Trump as the forty-fifth president was a pivotal point for so many things, including commercial approaches in the department, which changed due to the absence of political leadership and the new directions from that leadership once it finally arrived. In an alternate universe where Hillary Clinton would have been elected president, continuity at the political level would almost certainly have ensured Carter's initiatives scaled dramatically, even if he had not remained secretary. Under Trump, the road was more uncertain.

While the Senate quickly confirmed James Mattis as secretary of defense, the rest of the political leadership was slow to arrive, leaving vacancies that persisted throughout the entire Trump administration but were especially severe in its first two years. Continuity was initially provided by the holdover deputy secretary of defense, Robert O. Work, who worked closely with the vice chairman of the Joint Chiefs, Paul Selva, for the first six months of the Trump administration to push forward the innovation efforts begun by Carter.

Mattis, who had concurrently helmed the United States Joint Forces Command and served as NATO's Supreme Allied Commander Transformation, and went on to live in Silicon Valley and teach at Stanford after retiring from

active duty, immediately grasped the value of DIUx. He declared loudly and repeatedly during his first visit to Silicon Valley as secretary in August of 2017 that DIUx was here to stay (see fig. 9.3).[19] He even affixed a decal of DIUx's logo to the leather notebook he carried everywhere as a deliberate symbol of support.[20] In the weeks after his visit, DIUx staff enjoyed seeing their logo appear in photos when Mattis met with the Crown Prince of Saudi Arabia and other world leaders.

Even as the political leadership of the Trump Pentagon was slow to coalesce around a new strategy and budget, innovation continued to bloom. Secretary of the Air Force Heather Wilson announced the creation of AFWERX in August 2017. She described it as an island of misfit toys for entrepreneurs in the air force who, by embracing commercial approaches, would increase "lethality at a lower cost."[21] In June 2018, the Joint Artificial Intelligence Center (JAIC), pronounced "jake," became the latest special purpose office

Figure 9.3 DIUx in Silicon Valley

Secretary of Defense James Mattis with the DIUx team in front of a Saildrone autonomous ship (August 10, 2017)

Source: Office of the Secretary of Defense, Public Affairs.

within the Office of the Secretary of Defense (OSD) to join the innovation ranks, with a remit to accelerate the delivery and adoption of AI. In August 2018, the army announced the stand-up of Army Futures Command, whose entire premise was that new technological approaches were needed to compete with near-peer adversaries and that accessing them would require new kinds of acquisition processes and partnerships with the private sector.

Inspired by DIUx, partners and allies sent liaison officers to reside in Mountain View, delegations to visit, and started innovation cells of their own. The UK launched a Defence and Security Accelerator in late 2016. Conversations begun inside NATO in 2016 and 2017 ultimately matured, at the alliance's usual pace of working, into the announcement of the NATO Innovation Fund in 2022. The militaries of Australia, India, Singapore, and France launched innovation initiatives for themselves. Mattis went one step further by announcing that DIUx would become a permanent part of the department, to be known simply as Defense Innovation Unit, without the "X." The experiment had succeeded. Deputy Secretary Patrick Shanahan, who provided day-to-day support for DIUx in the initial months of his tenure, codified this change in a memo signed on August 3, 2018.[22]

At the same time, Mattis's embrace of DIU and other innovation initiatives was not fully shared by several appointees who came to serve him in key positions. Michael Griffin, the new under secretary of defense for research and engineering, placed the innovation agenda low on his priority list and generally viewed Silicon Valley with skepticism, seeing its technology as second class to "real science and engineering" that took place in defense labs by "real scientists and engineers." This despite having once been the chief operating officer of In-Q-Tel. In private conversations with the DIB and the director of DIU, he was even dismissive and, at times, outright condescending. This was especially unfortunate from DIU's perspective because, administratively, DIU had come to report to Griffin rather than the secretary or deputy. Griffin abruptly fired long-standing members of the DIB, including its chair, Eric Schmidt. The momentum the DIB gained through four years of work met a sudden end. A two-year hiatus ensued until the DIB was ultimately reconstituted in the next administration with Michael Bloomberg as its chair, but only after a lengthy "zero-based review" of boards and commissions further delayed its relaunch.

Griffin and his deputy Lisa Porter were ultimately let go after less than eighteen months on the job. Their departure was at once a relief to advocates of innovation and a worry, as the chief technology officer position at

the Pentagon was again vacant in a building already riddled with vacancies. That position was eventually filled for the last six months of the administration when President Trump's chief technology officer, thirty-three-year-old Michael Kratsios, was tapped to perform the additional role of the Pentagon's chief technology officer.[23]

Even though the vehicles Ash Carter created for innovation in 2015 had hoped for a different future in the Trump years, important progress was still made in the department's thinking about technology as a whole. The language around large system design and procurement used particularly by the air force for its Advanced Battle Management System displayed nuanced attention to how digital technologies and cloud computing will layer with the systems and installations that command and control military assets. A subsequent air force vice chief of staff, musing about the new approach to systems design, asked and answered his rhetorical question in the way a Silicon Valley programmer would have: "What exactly is ABMS?" he asked. "Is it software? Hardware? Infrastructure? Policy? The answer is yes to all."[24] This same approach to design informs the ambitious and beleaguered Joint All-Domain Command and Control (JADC2), a reimagining of cross-service command and control on an even grander scale.[25] The scale of JADC2 is so grand that many wonder how so many component systems will be tied together when the department is only at the earliest stages of moving to a cloud-based architecture and continues to define JADC2's scope.[26]

Whatever historians and defense analysts ultimately assess about the Trump Pentagon, it seems safe to conclude now that something of a paradox was at work. On the one hand, Trump secured astonishing budget increases for the Pentagon in his first two years in office, upping its budget by $65 billion in FY2018 and a further $17 billion in FY2019. During his presidency, DoD spending grew $98 billion, or 16 percent.[27] The infusion of new resources on a level not seen since 9/11 provided a remarkable moment of opportunity in a system so captured by its own inertia and strictures imposed by congressional line items that new money was often the only way to set off in new directions. But in the absence of a detailed strategy pushing significant changes upon the military services, led personally by the secretary and a fully seated political leadership, the infusion of new money was largely put toward existing programs of record and the incremental modernization they sought.

Even had a muscular strategy of commercial technology adoption been at the ready, the devolution by Congress of many acquisition authorities to the services as part of a package of reforms that split Acquisition, Technology,

and Logistics (AT&L) into two offices by now made a centralized strategy, developed by the secretary, more difficult to achieve. Trump, at this point, made matters even worse by rapidly cycling through defense secretaries. The abrupt resignation of Mattis in December 2019 in protest of the withdrawal from Syria was the first domino to fall. Trump left Mattis's deputy Patrick Shanahan in acting status for six months before nominating Secretary of the Army Mark Esper to the post, who he later fired by tweet. Acting secretary Christopher Miller's seventy-two days of service in the chaotic last months of the administration were marred by the events of January 6th and no notable policy accomplishments produced.[28]

Looking through the civil-military tumult that defined the Trump years, three moments from his stewardship of innovation at the Pentagon stand out. The first is his insistence on creating a space force over the wishes of the civilian and military leadership of the air force. The new miniature service has come to carve out an esprit de corps that unapologetically embraces the culture and modalities of innovation. A short walk down the new space force hallway in the Pentagon reveals displays filled with levity, pop-culture references, and *Star Trek* memorabilia, which stand in delightful, even subversive, contrast to the solemn, severe oil paintings of marine corps commandants on the opposite wall.[29] (US Space Force's motto, *Semper supra*, Latin for "always above," even plays homage to or perhaps is a playful twist on the US Marines' *Semper fidelis*, for "always faithful.")

The second was the sudden downscoping of DIU's largest contract after an incumbent firm, Oracle, which had not even competed for it, filed a protest with the Government Accountability Office (GAO). The chain of events is as follows. US Transportation Command (TRANSCOM), via DIU, awarded a production OTA contract to a firm named REAN Cloud after it successfully demonstrated a prototype that automated the movement of insecure legacy TRANSCOM applications to the cloud. The production contract was the largest DIU had awarded to that point, with a $950 million ceiling, though with far less funds initially obligated.[30] Two weeks after the award, the legacy cloud provider, Oracle, filed a protest with the GAO questioning REAN's partnership with Amazon Cloud Services as well as the use of the OTA contract vehicle for the award. Several days later, and more than two months before the GAO ruled on the protest, the Pentagon press secretary announced from the podium that the DoD was downscoping the original DIU contract by 90 percent to $65 million and narrowing its scope to use only by TRANSCOM and not across the DoD as enabled by the production OTA.[31] While the exact

reasons behind the downscoping remain contested, the collapse of this contract reverberates in Silicon Valley to this day as yet another reason why it's not worth it for new entrants to compete for department business.[32]

The third and perhaps most symbolic moment vis-à-vis innovation came earlier in Trump's presidency, in March 2017, when he christened the $13 billion USS *Gerald Ford*. On the deck of this new class of carriers, Trump vowed to expand the number of carriers from ten to twelve.[33] The whole episode, in the zero-sum game of weapons procurement, reinforced a preference for legacy platforms at the expense of experimentation with new ones and came at a time when the advent of Chinese "carrier-killer" missiles so clearly signaled the end of the carrier era. Instead of confronting the crisis of commissioning a ship that is unlikely to survive the opening salvos of war in the Pacific, Trump developed a peculiar obsession with the *Ford*'s electromagnetic catapult system and spent much of his remarks wondering aloud whether the navy should return to proven steam technology to launch planes.

Biden Takes the Helm

The Biden administration arrived in Washington to find the city ringed by barricades put in place after the events of January 6. It was also filled with a new consensus that China's aggregation of military capability needed to be urgently countered. The Chinese had been busy enacting their own ambitious military innovation strategy, termed "military-civilian fusion," in which every commercial innovation by industry will be made available to the People's Liberation Army. Xi Jinping announced this strategy almost in parallel to Carter's initiatives in 2015. By 2022, it was beginning to bear fruit of the kind that kept making US forces lose in war games. When coupled with well-funded Chinese national initiatives in multiple technology sectors, new energy existed in Washington for substantial change to US forces, statecraft, and industrial policy.

At the White House, the Biden National Security Council (NSC) established a deputy national security advisor for cyber and emerging technology and enlarged the NSC's technology directorate. President Biden went on to inhibit China's access to advanced microprocessors, curtail foreign investments in sensitive US technology, and implement the CHIPS Act, which underwrote the onshoring of microprocessor production and government-sponsored research for future chip generations. It was a stunning acceleration of the decoupling with China that began under Trump and the first major act of industrial policy in decades. The moves garnered bipartisan support and

deepened a kind of US-China cold war while making the geopolitical dimensions of commercial technology more visible.

At the Pentagon, DIU director Mike Brown, the former CEO of Symantec, was put forward to serve as under secretary for acquisition and sustainment. It was a historic nomination—the first person since David Packard with a software and Silicon Valley background to oversee the Pentagon's $200 billion procurement spend. Secretary Lloyd Austin, too, was initially vocal about commercial technology even as he disregarded the advice of venture capitalists and the heads of his own innovation initiatives on what policies to pursue. At his first major speech addressing the topic at the Reagan National Defense Forum in December 2021, Austin outlined a plan to double the Small Business Innovation Research (SBIR) program, open innovation hubs in Chicago and Seattle, and establish a Rapid Defense Experimentation Reserve to test new technologies.[34] The Biden team also announced an Emerging Capabilities Policy Office within the Office of the Secretary of Defense for Policy, created a Chief Digital and Artificial Intelligence Office, named the former head of machine intelligence at Lyft to lead it, and in late 2022 established the Office of Strategic Capital to liaise with private capital markets.[35] Space command also launched a commercial incubator named—you guessed it—SpaceWERX.

Even bigger pieces on the DoD chessboard were already in motion when the Biden team arrived. In his July 2019 guidance to the force, the newly installed commandment of the marine corps proposed sweeping changes to optimize the corps' ability to operate within denied areas in a fight in the Western Pacific.[36] Rocket artillery, drones, loitering munitions, electronic warfare, and littoral combat capabilities were in, while tanks were out, and artillery batteries, infantry, and helicopter lift were reduced. It was a rare example of a leader willing to remove the existing capability to make room for new ones. All hell broke loose in defense circles when this imaginative, thought-through plan surfaced.[37] As shocking as the idea of a marine corps without tanks and with three fewer infantry battalions was to retired marine generals and one former secretary of the navy, even more shocking to most was a sitting four-star general radically reshaping a military service to face down a new threat. It was as if force structure had become so immutable and unchanging that when someone altered it, no one initially believed it. With the support of Secretary Austin, the commandant presented detailed guidance affirming his initial judgments in March 2020.[38]

Change was thus in the air in the early Biden Pentagon. Encouragingly, a review by the Innovation Steering Group created by the deputy secretary surfaced a large and diverse ecosystem of DoD entities that had taken up the innovation mission. To illustrate their reporting relationship, the department printed one of its "horse-blanket" charts—Pentagon vernacular for a large diagram that could keep a horse warm. (See fig. 9.4 for a miniaturized version of this chart, published in May 2022.) The under secretary for research and engineering likewise compiled an online database of innovation entities, including a list and map view with eleven different categories of innovation institutions.[39]

DIU, meanwhile, kept chugging. With $892.7 million in contracts signed between June 2016 and the end of 2021, it began to approach its own kind of unicorn status in the Valley, that mythical billion-dollar valuation mark that denotes monumental success in the hypercompetitive world of entrepreneurship.[40] Companies funded by DIU had raised $11.7 billion from venture capitalists, with one of them, Anduril, joining Palantir and SpaceX as defense unicorns. The ecosystem Ash Carter wanted DIUx to seed was starting to take shape, with $20 of equity invested on average by the venture community for every $1 of prototype contracts that DIU awarded to a company.

By now, software factories were also beginning to deliver real capability. Five years after DIUx hacked its way to a new a tanker planning tool at the Combined Air Operations Center in Qatar, Kessel Run completed a total overhaul of that same center's entire command-and-control system, a significant milestone in the air force's in-house development of software.[41] The talent exchanges Carter called for in 2015 were also beginning, with Apple and other name-brand companies participating. AFWERX even launched a fellowship enabling midcareer officers, enlisted personnel, and civilians from all military branches to apply for short immersion experiences in venture capital firms, technology incubators, and start-ups.[42]

While there were many visible successes on the innovation front and many more nontraditional companies getting contracts from the services, there were early signs that the Biden DoD would ultimately not prioritize the innovation portfolio as much as Ash Carter did or spend political capital ensuring its success. Mike Brown's nomination was withdrawn after a whistleblower resurfaced complaints about whether DIU had misused hiring authority that DIU's general counsel had already adjudicated as spurious.[43] Rather than insist upon an expedited review by the inspector general, the secretary,

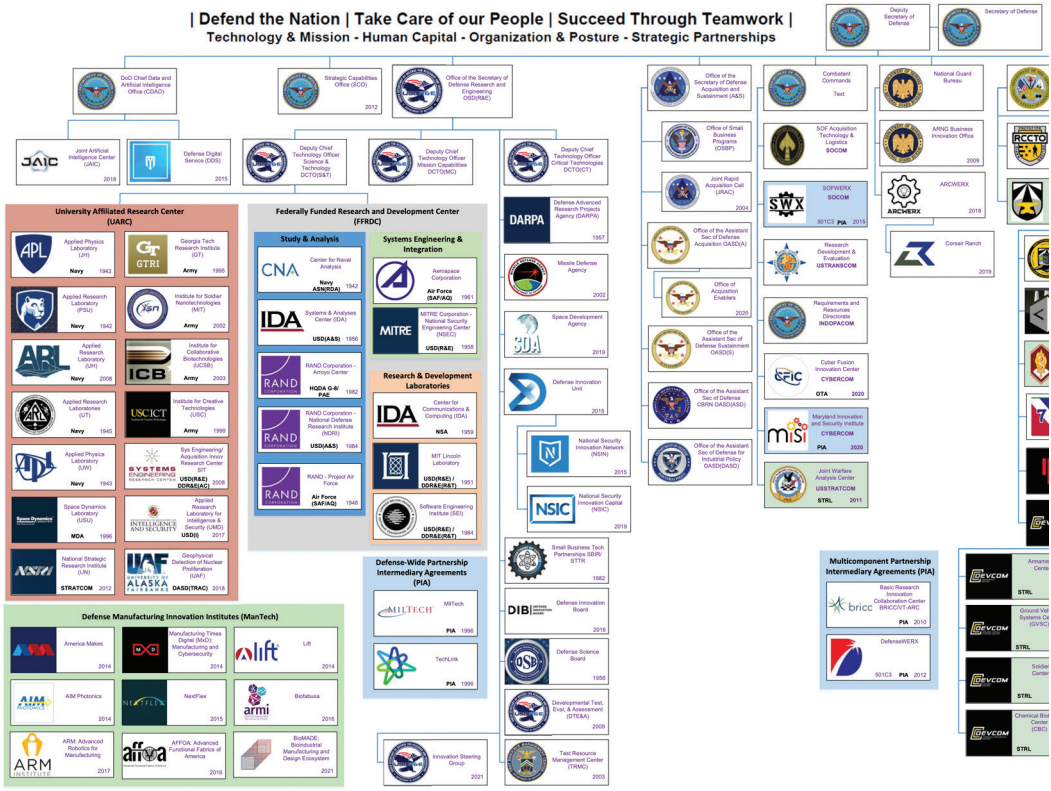

Figure 9.4 The Department of Defense Reporting Relationship Diagram

Source: Office of the Secretary of Defense, Innovation Steering Group: Michael Murray, Analyst, May 2022.

deputy secretary, and the White House took no steps at all. Brown's nomination collapsed, only to have the inspector general fully exonerate him one week after he stepped down as DIU director in September 2022.[44] It was a huge blow to advocates of innovation, who know the adage that "personnel is policy" is especially true in an administration's opening months and wished the department's leadership had gone to greater lengths to see Brown's nomination through.

The DIU budget was another sore spot. The political leadership of the Biden Pentagon kept suggesting lower levels than Congress was willing to fund, with DIU's expenditures at their high mark, reaching 0.01 percent of the DoD budget and less than 0.05 percent of the procurement budget. Rather

than growing into something on par with the size of DARPA and leading the adoption of commercial technology for the joint force, DIU's comparatively modest budget never gave it the heft many hoped for. Cuts at AFWERX, directed by the secretary of the air force, came the year after.

Other worrying signs continued to mount even before LaPlante, who was nominated in Brown's place, made his "tech bros" comments. Deputy Secretary Kathleen Hicks did not visit DIU on her first trip to Silicon Valley.[45] When asked by a group of entrepreneurs how their technology could most quickly enter the department, she suggested they explore SBIRs—a type of grant venture-backed companies are mostly ineligible to receive because of congressional small business set-asides prioritizing sole-owner enterprises.

In Silicon Valley, a series of SBIR awards with no further investment signals that you couldn't hack it—that venture investors looked at your technology and business model and declined to invest. As one former staff member on the Senate Armed Services Committee noted, "the just-under $2 billion that DoD spends on SBIR in minuscule, thinly spread tranches is a trifling amount compared to the $400 billion that venture capitalists have recently spent on innovation . . . or the $1.8 trillion private equity industry that is a barely tapped resource for DoD."[46]

McKinsey & Company similarly found that, despite all the innovation initiatives, the portion of the DoD budget dedicated to early-stage technology had not changed over time. By McKinsey's methodology, early-stage innovation accounted for only $34 billion of the $857 billion earmarked for US national security spending for 2022—approximately 4 percent of the total. The analysis further noted that this share had not changed significantly from prior years, nor was it programmed to change across the five-year future budget.[47]

Today in Ukraine, Tomorrow in Taiwan

As the Pentagon's policy agenda took greater shape toward the midpoint of Biden's term, any assessment of defense innovation would necessarily reach mixed conclusions. Individual services and the Office of the Secretary of Defense have more innovation entities than ever before, and more of them have connectivity with the Valley. Larger amounts are being spent on more CSOs year after year. But a composite military vision or approach that fully leverages commercial technology into a new construct for joint warfighting and an associated plan for force design and development is proving elusive. Nor are resources flowing to innovation at the scale needed for the department to realize Ash Carter's "fast-follower" vision. To the extent present military and civilian leadership is articulating a strategy, it is one built, for the most part, on a continuation of previous programmatic and budgetary trendlines with marginally greater inclusion of emerging technologies and only a few significant departures from historical baselines—with the marine corps being one of the more commendable. If there is a strategy for losing a future war with China, this is it. And yet, developments in international security so mirrored the world foreseen in 2015–16 by the original cast of defense innovators that the intellectual constructs they built their enterprises around now appear prophetic.

The first surprise of Biden's presidency occurred in May of 2021 when cyberattacks launched by a ransomware group likely based in Russia caused

a shutdown of the 5,500-mile Colonial Pipeline, the single most important energy artery in the United States. Gas prices surged in the Southeast. Only quick action by authorities and the company averted a further cascade of effects in the lower forty-eight states.

The second surprise happened on July 27, 2021, when China launched the world's first nuclear-capable hypersonic weapon—an arrowhead-shaped sheath of titanium that flies at ten times the speed of sound, can't be seen by early warning radars, and can evade all known defenses. The chairman of the Joint Chiefs called this China's "Sputnik moment."[48] The USS *Ford*'s malfunction-prone electromagnetic catapult was suddenly less of an issue for the navy than the ship's radar signature.

The third surprise occurred two months later when unsophisticated commercial drones with loitering munitions decimated Armenian troops in the September–October 2021 conflict with Azerbaijan. Together with Russia's earlier, if unsuccessful, deployment of autonomous tanks in the Syrian civil war, these developments signaled that autonomous weapons of all kinds, some expensive and sophisticated, others cheap and attritable, would be persistent features on future battlefields.

The fourth and most significant surprise occurred when Putin ordered his forces into Ukraine. The conflict immediately had a kind of *Ghost Fleet: A Novel of the Next World War*–meets–MacGyver quality, with the most sophisticated weapons platforms fielded by the West and Russia, enmeshed together on the battlefield alongside lower-tech innovations that were lethal on their own and even more lethal when used in conjunction with major weapons systems.[49] To list just a few of the battlefield developments beyond those already mentioned in this paper's introduction: uncrewed small boats attacking Russian navy warships; Soviet-era surveillance drones modified by Ukraine being used to strike targets deep in Russian territory; $20,000 Iranian-made kamikaze drones built with 82 percent American technology shutting off the power in Kyiv in winter; Ukraine launching missiles costing between $140,000 and $500,000 to down them; DJI drones used by infantry units on both sides of the conflict; and spotter teams driving pickup trucks streaming video for targeting via a Starlink terminal connected to a generator in the back.[50] This is a war where the most lethal weapons system on the ground, the US-provided high-mobility artillery rocket system (HIMARS), is being directed where to fire by something that can be bought on Amazon.

Lieutenant General Jack Shanahan (Ret.), the former director of Project Maven and the JAIC, notes that "we are in a critical 'bridge period' where the

most creative and innovative warfighters will figure out how to mate legacy equipment with emerging technologies, and along the way come up with novel operating concepts."[51] Commercial technology in Ukraine thus made for a deus ex machina moment, where god (and Elon Musk) reversed a seemingly hopeless situation to stop an invading Russian army and force it far into retreat.

Contrary to LaPlante's assertion, the tech "bros" and their tech are in Ukraine and matter to the fight. Microsoft and US Cyber Command repelled Russian cyberattacks long enough to keep Ukraine's internet running and allow the Ukrainian government to convert essential IT infrastructure and citizen services to cloud enclaves.[52] Elon Musk rushed in with Starlink terminals and repositioned his constellations of satellites. Amazon ferried in civilian supplies and ferried out 10 million gigabytes of tax, property records, banking, and other critical data in suitcase-sized "Snowball Edge" solid-state storage devices.[53] Capella Space supplies both the Ukrainian military and CNN with real-time imagery. Palantir is driving a new digital kill chain fueled by open-source intelligence.[54] Anduril has "hardware, software, and people in Ukraine," with Palmer Luckey and teams of engineers even traveling to the front to improve the software powering Anduril drones.[55] Counter-drone systems, including those fielded by firms that worked with DIU, are also on the battlefield, alongside half a dozen other companies in the DIU portfolio.[56] As Eric Schmidt's trip report from Kyiv makes clear, so too has Ukraine's own tech sector mobilized, creating apps for prosecuting the war and providing a digital backbone to the operation of the Ukrainian government that Russian state cyberspace operators have not yet succeeded in taking down. "For me," Schmidt writes, "the war answers a central question: what can technology people do to help their government, and the answer is a lot."[57]

Indeed, the conflict in Ukraine has affirmed the importance of major weapons platforms and the companies that make them. In fact, we all stand in debt to the heroic leadership LaPlante and his colleagues in Acquisition and Sustainment have provided—for getting platforms and munitions to the battlespace, mobilizing the defense industrial base when it became apparent our stores of advanced munitions were woefully inadequate, restarting production of key armaments whose factory lines had idled for fifteen years or more, and establishing a new command to funnel US and other armaments to Ukraine.

But it would be wrong and even tragic to read the platform-on-platform dynamics in Ukraine as a reassertion of warfighting paradigms they were built for or as justification for preserving the industrial base in the form it exists in

today. To do this would be to miss the beguiling hybridity and asymmetry of the battlefield that has evolved over the last nine months, as well as parallel developments in other battlespaces, such as Armenia-Azerbaijan, North Korean drone incursions into Seoul, and the dramatic experimentation with commercial technologies by the People's Liberation Army. These developments suggest that much of our future can be glimpsed today.[58]

Shortly after Bill LaPlante made his remarks about Silicon Valley tech, Northrop Grumman publicly revealed the new B-21 strategic bomber, which LaPlante oversaw as head of acquisition for the air force.[59] With a reported unit cost of $692 million, the total program to develop, purchase, and operate 100 B-21s will exceed $200 billion.[60] In response, *Duffel Blog*, a satirical publication focusing on the military, published an article titled "B-21 nukes DoD budget."[61] Its key faux quote came in the third graph. "When we talk about low observability, it is incredibly low observability," said Kathy Warden, chief executive of Northrop Grumman. "You'll hear it, but you really won't see it eat into the defense budget until it's too late."

What makes the article's satire biting is the dilemma it highlights about how exquisite platforms impose tremendous future opportunity costs. This is not to say that the United States does not need some exquisite platforms but rather to question what adjacent possibilities exist if even a fraction of the resources dedicated to large programs were used to experiment and scale other technological approaches.

For the cost of a single aircraft carrier, the navy could purchase 21,702,838 Starlink terminals—or more than 400,000 for each of the United States' more than fifty treaty allies we are obligated to defend if attacked.[62] The cost of providing over 20,000 Starlink terminals and continuing service in Ukraine is on par with a couple of F-35s, whose internal processor is 800 times slower than commercially available NVIDIA chips.[63] If LaPlante admitted to the tech "bros" that their gaming consoles have higher specs than all deployed US military hardware, they might ask who was really the one getting "liquored up."

The Risks of Strategic Surprise

We are left, then, at an uncomfortable juncture, with radically different assessments of the Ukraine conflict and what affirmative policy agenda the Pentagon should pursue in the still-evolving war's wake. The debate, to some degree, boils down to Clayton Christensen's innovator's dilemma—to what extent should we discard the old in favor of the new as our adversaries threaten to displace our dominant position? The Pentagon, much like Apple's

spinning out of General Magic in 1990, must now decide how much of the radical future it wants to import back in. Stasis and paradigm shifts each have risks. The question after Ukraine is what new balance to strike.[64]

As we strike this balance by recapitalizing older systems with new technology and building new systems around new operational concepts, it's worth enumerating the lessons that emerge from our exploration of defense innovation across three presidential administrations.

The first lesson is that the Pentagon will not win a future war without embracing commercial and emerging technology in equal or greater measure than its adversaries. China's strategy of civil-military fusion is thus a pacing threat of its own. Second, technology is only a part of how modern militaries field greater capability. As the head of OSD-Policy's new Emerging Capabilities Policy Office has powerfully argued in prior scholarship, human capital, institutional structures, and culture are crucial to adopting and spreading innovation.[65] In this way, enumerating organizations flying the banner of innovation is far easier than pursuing a strategy to bring innovation into the department at scale. Third, a massive flow of private capital and talent toward start-ups focused on developing technology for the Pentagon creates new and better options than existed even two years ago.[66]

Figure 9.5 visually illustrates this investment trend, which is fueled by Thomas Tull's US Innovative Technology Fund, America's Frontier Fund, a16z American Dynamism Fund, Embedded Ventures, Shield Capital, Razor's Edge Ventures, Irongate Capital Advisors, and Lux Capital. When taken in aggregate, this mobilization of new markets, together with defense primes increasingly working with new entrants, offers a path for the US to outcompete China with existing strengths and institutions.

A full articulation of what policy agenda to pursue is beyond the scope of this paper. But here is a sketch. Elevate DIU back to reporting to the secretary of defense and add to its mission the development of joint operational concepts powered by new technological approaches. Recruit a new director of standing in the commercial technology world. Change the metric by which DIU is judged from the number and size of OTA contracts let—a still important measure of technology adoption—to driving change in key operation plans, especially in the Indo-Pacific, and ultimately changing what gets bought across DoD's Future Years Defense Program. Build new linkages between DIU, the COCOMs (Combatant Commands), OSD-Policy, Forces & Plans, and Emerging Technologies Policy. With so many approaches pioneered by DIU at a "tipping point" just short of viable scale, work with Congress to

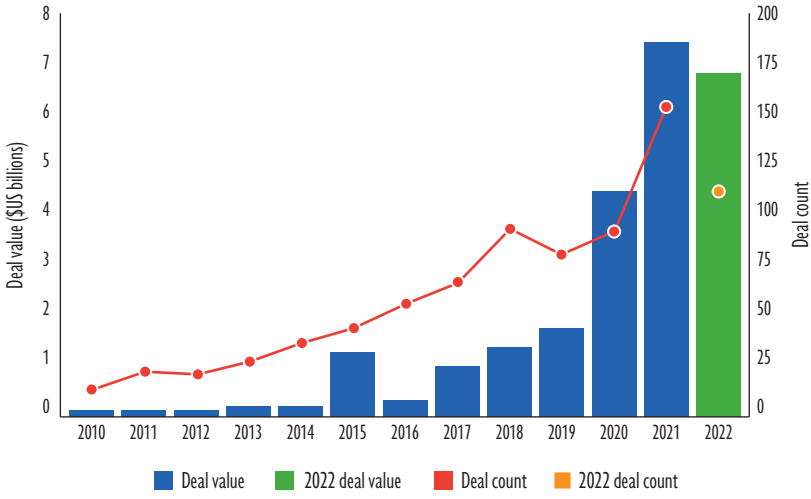

Figure 9.5 US Venture Investment in Defense and Aerospace, 2010–October 2022

Note: 2022 data as of October 13, 2022.
Source: Marina Temkin, "VCs Go outside Their Comfort Zone with Bets on Defense Tech," *PitchBook*, October 26, 2022 (data through October 13, 2022).

quickly ramp up DIU's budget to a trial period of $1 billion annually for three years and keep it there if results merit it. Do the same for other organizations driving commercial technology adoption in OSD and the services.

Give the innovation organizations on that horse-blanket chart marching orders. Have the deputy secretary of defense develop a top-down strategy for joint commercial technology adoption that meets "the thousand flowers blooming" from the bottom up. Hire more tech "bros" all across the department, especially in the outer E Ring of the Pentagon, where top leadership have offices so that the next leaders of Acquisition & Sustainment and Research & Engineering can aggressively exploit advances in commercial technology rather than view it as a boutique part of their responsibilities. Congress, too, must do its part. If DIU and other innovation entities are to equip DoD for a post-Ukraine battlefield, they must be funded aggressively. Congress must also raise reprogramming thresholds, especially if continuing resolutions will remain the norm and continue growing pools of flexible multiyear funding for technology. Senators and representatives must show real leadership, given the shifts that must be made to meet a rising China, by taking votes that will ultimately keep their constituents safer, even if this sometimes means giving up legacy defense jobs in their districts.

The last lesson to draw from fourteen years of defense innovation at this critical moment of resetting and relaunching the innovation agenda is that, like others innovating in large organizations, innovators rarely win. Scholars of security policy have long noted the preeminence of politics and organizational interests in shaping what capacities defense institutions develop. The literature on this point is voluminous and depressing, with self-interest and established ways of warfighting almost always trumping new notions of prevailing threats, objectives derived from planning processes, or technocratic visions of the possible.[67] Stasis is even more likely in the present political environment, with its stark divides across and within the parties.

Yet all hope is not lost. General Magic ceased operations in 2002 and was liquidated in 2004. But the magic it made lives on. Apple brought the iPhone to market in 2007, a product that made it the most valuable company in the world. While its competitors have tried mightily to unseat Apple's dominance in the ensuing fifteen years, it is simply too far ahead today to be beaten. The question now is whether the Pentagon will follow suit and architect at scale the battlefield innovations it has incubated within. Advocates of innovation must keep pressing. Leadership must back them to the hilt. The sound of glass breaking is the melody of progress.

Notes

The author dedicates this paper to the memory and immense legacy of Ash Carter. Thanks to Richard Danzig, Michael Brown, Raj Shah, Josh Marcuse, Jack Shanahan, Matt Cordova, Jared Dunnmon, Jonathan Reiber, Michael J. Boskin, and Kiran Sridhar for reviewing earlier drafts.

1. Mark Sullivan, "'General Magic' Captures the Legendary Apple Offshoot That Foresaw the Mobile Revolution," *Fast Company*, July 26, 2018.

2. Wikipedia entry, "General Magic" (accessed December 28, 2022).

3. Clayton M. Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Boston: Harvard Business School Press, 1997).

4. Valerie Insinna, "LaPlante Pokes Silicon Valley 'Tech Bros,' Calls for Increased Munitions Production for Ukraine," *Breaking Defense*, November 8, 2022; Eric Lofgren, "Getting Weapons into Production with USD A&S Bill LaPlante," *Acquisition Talk Podcast*, November 10, 2022.

5. Nick Siani, "Forging the Defense Industrial Base for the Digital Age" (rebuttal to LaPlante), *Defense Scoop*, December 1, 2022.

6. Office of the Under Secretary of Defense for Research and Engineering, "Critical Technology Areas," CTO.mil (accessed December 28, 2022); "Technology Vision for an Era of Competition," memorandum by Under Secretary of Defense

Heidi Shyu, February 1, 2022; Office of the Under Secretary of Defense for Research and Engineering, "DoD Announces First Set of Projects to Receive Funding from the Pilot Program to Accelerate the Procurement and Fielding of Innovative Technologies (APFIT)," US Department of Defense press release, July 19, 2022.

7. US Department of Defense (DoD), *Military and Security Developments Involving the People's Republic of China 2022*: *Annual Report to Congress*, November 29, 2022; Office of the Director of National Intelligence, *Annual Threat Assessment of the US Intelligence Community*, February 2022; US-China Economic and Security Review Commission, *2022 Report to Congress*, 117th Cong., 2d sess., November 2022.

8. Ashton B. Carter, Marcel Lettre, and Shane Smith, "Keeping the Technological Edge," in *Keeping the Edge: Managing Defense for the Future*, ed. Ashton B. Carter and John P. White (Cambridge, MA: MIT Press, 2001), 129–64, available at the Belfer Center for Science and International Affairs, https://www.belfercenter.org/sites/default/files/legacy/files/kte_ch6.pdf.

9. Christopher Kirchhoff, "Reshaping National Security Institutions for Emerging Technology," chap. 5 in *America's National Security Architecture: Rebuilding the Foundation*, ed. Nicholas Burns and Jonathon Price (Washington, DC: Aspen Institute, 2016), 86–96; Christopher Kirchhoff, "An Even Flatter World: How Technology Is Remaking the World Order," chap. 5 in *The World Turned Upside Down: Maintaining American Leadership in a Dangerous Age*, ed. Nicholas Burns, Leah Bitounis, and Jonathon Price (Washington, DC: Aspen Institute, 2017), 93–99; Christopher Kirchhoff, "Looking Back to Go Forward: Strategic Mismanagement of Platform Technologies and the Race for the Future," Alliance for Securing Democracy, July 23, 2020.

10. Sharon Weinberger, *The Imagineers of War: The Untold Story of DARPA, the Pentagon Agency That Changed the World* (New York: Penguin Random House, 2018); Regina E. Dugan and Kaigham J. Gabriel, "'Special Forces' Innovation: How DARPA Attacks Problems," *Harvard Business Review* (October 2013).

11. Christian Brose, *The Kill Chain: Defending America in the Future of High-Tech Warfare* (New York: Hachette Books, April 2020).

12. Beth Duff-Brown, "Secretary of Defense Ashton Carter Unveils Cyber Strategy, Calls for Renewed Partnership with Silicon Valley," *CISAC News*, Stanford University Center for International Security and Cooperation, April 23, 2015.

13. Jon Harper, "Special Report: 2021 Brought Another 'Banner Year' for OTAs," *National Defense Magazine*, February 3, 2022.

14. Fred Kaplan, "The Pentagon's Innovation Experiment," *MIT Tech Review*, December 19, 2016.

15. Kessel Run website, https://kesselrun.af.mil.

16. DoD, "Secretary Carter Names Additional Members of Defense Innovation Advisory Board," Department of Defense press release, July 26, 2016.

17. See Eric Schmidt, "Remembering Ash Carter: The Innovative Secretary of Defense Who Changed the Pentagon, Silicon Valley, and the Trajectory of Our Nation," Special Competitive Studies Project, January 26, 2023; Defense Innovation

Board, "Software Acquisition and Practices (SWAP) Study," May 2019; Milo Medin and Gilman Louie, "The 5G Ecosystem: Risks and Opportunity for DoD," Defense Innovation Board, April 3, 2019; C. Todd Lopez, "DoD Adopts 5 Principles of Artificial Intelligence Ethics," Department of Defense News, February 25, 2020.

18. See Directorate for Digital Services, https://www.dds.mil/work.

19. "Media Availability with Secretary Mattis at DIUx," Department of Defense (transcript), August 10, 2017; Tom Simonite, "Defense Secretary James Mattis Envies Silicon Valley's AI Ascent," *Wired*, August 10, 2017.

20. This was no accident—Mattis did it as a deliberate signal to the rest of DoD. James Mattis, personal communication to author, January 19, 2023.

21. Office of the Secretary of the Air Force, "Air Force Opens Doors to Universities, Small Businesses and Entrepreneurs to Boost Innovation," Public Affairs press release, July 21, 2017.

22. Deputy Secretary of Defense Patrick Shanahan, "Redesignation of the Defense Innovation Unit," memorandum, August 3, 2018, available at *FedScoop*, https://www.fedscoop.com.

23. DoD, "Michael Kratsios, DoD Biography." The thirty-three-year-old Kratsios, who had gained exposure to technology investing as chief of staff to Peter Thiel, had earlier come under criticism for serving as Trump's acting science advisor with only an undergraduate degree in politics and certificate in Hellenic studies. Scott Waldman, "Trump's Science Advisor, Age 31, Has a Political Science Degree," *Scientific American*, February 14, 2018.

24. "Advanced Battle Management System (ABMS)," *In Focus*, Congressional Research Service IF11866, February 15, 2022.

25. "Joint All-Domain Command and Control (JADC2)," *In Focus*, Congressional Research Service IF11493, January 21, 2022.

26. Nand Mulchandani and Lt. General (Ret.) John N. T. "Jack" Shanahan, "Software-Defined Warfare: Architecting the DoD's Transition to the Digital Age," Center for Strategic and International Studies, September 6, 2022.

27. Andrew Lautz, "Meet the Biden War Budget, Same as the Trump War Budget," *Responsible Statecraft*, Quincy Institute, January 5, 2023.

28. Beatrice Peterson and Morgan Winsor, "Former Acting Defense Secretary Testifies He Was Trying to Avoid Another Kent State on Jan. 6," ABC News, May 12, 2021.

29. Office of the Secretary of the Air Force, "USSF Hallway Unveiling," Air Force News Photo, released December 18, 2020.

30. Billy Mitchell, "Pentagon Awards Nearly $1B Contract for Cloud Migration to REAN Cloud," *FedScoop*, February 7, 2018.

31. Billy Mitchell, "Pentagon Scales Back Massive Cloud Contract by More Than 90 Percent," *FedScoop*, March 6, 2018.

32. Billy Mitchell, "REAN Cloud Claims It Got No Explanation for DoD Cloud Contract Scaleback," *FedScoop*, March 9, 2018; Luke Stangel, "Report: Oracle CEO

Privately Complained to Trump about Amazon's Odds to Win $10B Pentagon Cloud Contract," *Silicon Valley Business Journal*, April 5, 2018.

33. Scot Paltrow, "Special Report: Aircraft Carriers, Championed by Trump, Are Vulnerable to Attack," Reuters, March 9, 2017.

34. Lloyd J. Austin III, "Remarks by Secretary of Defense Lloyd J. Austin III at the Reagan National Defense Forum (as delivered)," US Department of Defense, December 4, 2021.

35. Chief Digital and Artificial Intelligence Office website, https://www.ai.mil; US Department of Defense, "Secretary of Defense Establishes Office of Strategic Capital," press release, December 1, 2022.

36. 38th Commandant of the Marine Corps, *Commandant's Planning Guidance*, July 16, 2019.

37. Paul McLeary and Lee Hudson, "How Two Dozen Retired Generals Are Trying to Stop an Overhaul of the Marines," *Politico*, April 1, 2022; Mark F. Cancian, "The Marine Corps' Radical Shift toward China," Center for Strategic and International Studies, March 25, 2020; Dov S. Zakheim, "Gen. Berger's Radical Plan to Reshape the Marines Needs Work—but Quickly," *The Hill*, April 22, 2022.

38. US Department of the Navy, *Force Design 2030*, US Marine Corps, March 2020.

39. Office of the Under Secretary of Defense for Research & Engineering, "Innovation Organizations," https://www.ctoinnovation.mil/innovation-organizations (accessed January 3, 2022).

40. DoD, *DIU Annual Report 2021*, Defense Innovation Unit News, January 25, 2022.

41. Kessel Run and Ninth Air Force, "AFCENT's 609th AOC Shifts to User-Focused Software Suite," US Air Forces Central press release, December 7, 2022.

42. Defense Ventures website, https://www.shift.org/dv (accessed January 3, 2022).

43. The complaint against Brown was authored by a single individual. The primary allegation was that Brown had too aggressively used personnel authorities to attract and pay Silicon Valley talent—which was, and is, the chartered mission of DIU. The complaint enumerated a number of other subsidiary allegations as well, including that junior officers overseeing the office snack fund, Snack-O, used an insufficiently robust system of cash accounting to buy Cheetos and coffee cups for the office Keurig. The inspector general, who had initially declined to investigate the complaint, suddenly said it would investigate the complaint and that it needed a year or more to do so.

44. Courtney Albon, "Inspector General Clears Former DIU Chief of Ethics Allegations," *Defense News*, September 13, 2022.

45. Valerie Insinna, "After Hearing Silicon Valley Complaints, Hicks Says No 'Magical' Fix to Acquisition," *Breaking Defense*, April 11, 2022.

46. Bill Greenwalt, "DIU's Director Tried to Overcome a Calcified Defense Innovation System. It Beat Him. Now What?" *Breaking Defense*, August 29, 2022.

47. Eric Chewning, Will Gangware, Jess Harrington, and Dale Swartz, "How Will US Funding for Defense Technology Innovation Evolve?" McKinsey & Company, November 4, 2022. The authors conclude their report with a double caution: "With such relatively low funding for defense technology innovation, it is unclear whether there will be enough capital to support the high-tech priorities embedded in the DoD's future architecture designs. Similarly, defense start-ups and commercial technology firms (as well as investors across public and private markets) may question whether the demand for defense tech innovation is sufficient to justify a focus on these offerings."

48. Sara Sorcher and Karoun Demirjian, "Top US General Calls China's Hypersonic Weapon Test Very Close to a 'Sputnik Moment,'" *Washington Post*, October 27, 2021.

49. P. W. Singer and August Cole, *Ghost Fleet: A Novel of the Next World War* (New York: Eamon Dolan/Houghton Mifflin Harcourt, 2015).

50. Paul McCleary and Erin Banco, "Ukraine Used Home-Modified Drones to Strike Russian Bases," *Politico*, December 7, 2022; "Ukraine Defends against Russia's Inexpensive Drones with Far Costlier Missiles," *New York Times*, January 3, 2023.

51. Lieutenant General John N. T. "Jack" Shanahan, correspondence with the author, January 5, 2022.

52. Brad Smith, "Defending Ukraine: Early Lessons from the Cyber War," *Microsoft on the Issues* (blog), June 22, 2022; Lauren Naniche, Jafer Ahmad, and Joe Wang, "Lessons Learned from Ukraine: Protecting Nations' Digital Freedom from External Aggression," Special Competitive Studies Project, December 16, 2022.

53. Russ Mitchell, "How Amazon Put Ukraine's 'Government in a Box'—and Saved Its Economy from Russia," *Los Angeles Times*, December 15, 2022.

54. David Ignatius, "How the Algorithm Tipped the Balance in Ukraine," *Washington Post*, December 19, 2022.

55. Kevin Costelloe, "Anduril Founder Confirms Involvement in Ukraine," *Orange County Business Journal*, July 13, 2022.

56. Ukrainian Ministry of Defense, "Ukraine Will Receive Titan Counter-UAV Systems from the USA," press release, September 29, 2022.

57. Eric Schmidt, "The First Networked War: Eric Schmidt's Ukraine Trip Report," Special Competitive Studies Project, September 13, 2022.

58. In the last week of 2022, five drones from North Korea crossed the border into South Korea largely undetected, with one penetrating the airspace of Seoul, prompting a public apology from the South Korean president.

59. Coined by the political journalist Michael Kinsley, a *Kinsley gaffe* occurs when a politician reveals a truth they hold that they did not intend to admit. See Wikipedia entry "Political Gaffe" (accessed December 29, 2022).

60. W. J. Hennigan, "Exclusive: The Making of the US Military's New Stealth Bomber," *Time*, December 3, 2022.

61. "B-21 Nukes DoD Budget," *Duffel Blog*, December 9, 2022.

62. Ben Watson, "Mapped: America's Collective Defense Agreements," *Defense One*, February 3, 2017.

63. Brose, *Kill Chain*, 56–57.

64. Special Competitive Studies Project, "Defense Panel Interim Panel Report: The Future of Conflict and the New Requirements of Defense," October 5, 2022.

65. Recent scholarship has called this "adoption-capacity theory." See Michael C. Horowitz, *The Diffusion of Military Power: Causes and Consequences for International Politics* (Princeton, NJ: Princeton University Press, 2010). See also Steven Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1994).

66. Mark Sullivan, "Silicon Valley Wants to Power the US War Machine," *Fast Company*, November 1, 2021.

67. Harvey M. Sapolsky, Eugene Gholz, and Caitlin Talmadge, *US Defense Politics: The Origins of Security Policy*, 4th ed. (London: Routledge, 2020).