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ARMING THE EAGLE, OUTPACING THE DRAGON
UNDERSTANDING AND OUT COMPETING CHINA'S DEFENSE ACQUISITION AND INNOVATION SYSTEM

by Dan Ward and Matt MacGregor

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Executive Summary

Over the past two decades, the Chinese government has made considerable progress in transforming the People's Liberation Army (PLA) into a modern force through strategic reorganization, highly focused warfighting concepts, and technological advances.

THE DEPARTMENT OF DEFENSE (DOD) NEEDS TO BETTER UNDERSTAND CHINESE STRATEGIES AND APPROACHES TO TECHNOLOGY DEVELOPMENT, INNOVATION, AND DEFENSE ACQUISITION.

To address the challenge of a competitor gaining military parity, the Department of Defense (DoD) needs to better understand Chinese strategies and approaches to technology development, innovation, and defense acquisition. This understanding will enable the United States to respond more effectively in countering those strategies and potentially provide insights that can drive internal change to our own systems. This paper aims to help increase the DoD's understanding of the PLA's strategy around acquisition and innovation.

The first thing to understand is that the PLA's technical attention and resources are primarily spent on incorporating and leveraging inventions that come from elsewhere, a strategy described as *absorptive*. This absorptive strategy has two main threads: adoption and integration.

- Adoption involves acquiring technology from other countries through measures such as reverse engineering, purchasing systems from other countries, and intellectual property theft.
- Integration refers to blending defense and commercial interests, as with the People's Republic of China's Military-Civil Fusion policy.

This absorptive strategy is responsible for most of the PLA's current military capabilities, although it has also taken significant steps to increase domestic production of new technologies, both in terms of manufacturing and original Research and Development (R&D).

The PLA's collective efforts have produced positive results in some major mission areas. The 2021 DoD report on China's military developments noted that "China stands at, or near, the frontier of numerous advanced technologies." At the same time, the absorption strategy faces several limiting factors, including the difficulty of copying advanced technologies.

In contrast, the DoD's acquisition strategy can best be described as generative. This approach prioritizes domestic development of new technologies and seeks to generate original military systems that outperform those used by other countries. While this approach is responsible for most of the DoD's capabilities, the Department is increasingly using absorptive strategies that integrate commercial technologies into military systems.

The current competitive environment between the DoD and PLA can therefore be described as primarily an absorptive/generative scenario, although it is admittedly a dynamic and evolving situation, not a static one. Nevertheless, the absorptive/generative label describes the majority of current acquisition efforts, and in this scenario the United States faces two main risks:

1. **Replication:** An adversary gets access to DoD system specifications and replicates the technology, reducing the DoD's tech overmatch.
2. **Exploitation**: An adversary gets access to DoD system specifications and identifies vulnerabilities it can exploit.

To address the risks and opportunities in the current competitive environment, the DoD should consider these seven recommendations:

1. **Cultivate Strategic Empathy:** Make a determined effort to understand the PLA's posture and technology development strategies.
2. **Be a Better Customer/Business Partner:** Remove cultural and process barriers that prevent the DoD from leveraging solutions from innovative companies (of all sizes).
3. **Increase Use of Portfolio Management:** Manage requirements, budgets, and risks at the portfolio level rather than as isolated programs.
4. **Operate at "Bewildering Velocity":** Remove barriers to speed and make rapid investments in a diverse portfolio to produce an unpredictable stream of fieldable prototypes.
5. **Reduce Benefits of Copied Systems:** Build for the short term and prioritize adaptable designs.
6. **Became a More Integrated Player:** Establish more collaborative partnerships with industry to shape Independent Research and Development (IR&D) investments made by companies.
7. **Maximize University Talent:** Strengthen partnerships with the National Science Foundation and relevant universities.

Introduction

Over the past two decades, the Chinese government has made considerable progress in transforming the People's Liberation Army (PLA) into a modern force, and has publicized its goals of achieving technical parity with the U.S. military in the near future. As the Department of Defense (DoD) 2021 report to Congress explained, the People's Republic of China's (PRC's) intent is to "match or surpass U.S. global influence and power, displace U.S. alliances and security partnerships in the Indo-Pacific region, and revise the international order to be more advantageous to Beijing's authoritarian system and national interests."

This situation has wide-ranging implications for many aspects of U.S. policy, from diplomacy to economics to defense. The "pacing challenge of China" is particularly acute in the domain of military technology. To address this challenge, the DoD needs to better understand the PLA's strategies and approaches to military technology development, innovation, and defense acquisition.

This paper provides an overview of how the PLA develops new military systems and describes some strengths and weaknesses of that approach. It compares the PLA's approach with the DoD's acquisition posture, presents a brief risk analysis, and offers recommendations on how the DoD's acquisition community can counter the PLA's strengths and maintain a technological advantage that deters aggression.

China's Acquisition Strategy Is Primarily *Absorptive*

A majority of the PLA's current armaments and technical systems are of foreign origin, either purchased or copied from other countries. Unlike the DoD, the PLA's military technology complex is not primarily structured to develop new systems based on original, domestic Research & Development (R&D). Instead, the PLA's technical attention and investments are primarily spent on incorporating and leveraging inventions that come from elsewhere—a strategy described as *absorptive*.

A 2018 research brief by the University of California Institute on Global Conflict and Cooperation defined the absorption strategy as "the acquisition of foreign technologies and know-how and the digestion, adaptation, and re-engineering of these capabilities to local needs and conditions."

This approach constitutes a genuine type of innovation, in that it establishes new military capabilities that enable the PLA to perform its functions and missions. It would be a mistake for the DoD to dismiss the absorptive strategy as "not innovative" and inherently inferior to other approaches. It would also be a mistake to overestimate the efficiency or effectiveness of the absorptive strategy. Instead, the DoD needs to understand the absorptive strategy as it is implemented by the PLA, and then introduce effective counterstrategies.

The PLA's absorptive approach is multi-faceted and has two primary threads. The first and best-known thread is the adoption of technology from other countries through measures such as reverse engineering, capital investments in emerging technology companies, purchases of systems from other countries (primarily Russia), and intellectual property theft. These activities often overlap and reinforce each other, as when China purchased a small number of Russian Su-27 fighters and S-300 missile systems, then reverse-engineered and copied the technology to produce larger quantities of its own domestic versions, the J-11 fighter jet and HQ-9 surface-to-air missile system, respectively.

THE PLA'S TECHNICAL ATTENTION AND INVESTMENTS ARE PRIMARILY SPENT ON INCORPORATING AND LEVERAGING INVENTIONS THAT COME FROM ELSEWHERE—A STRATEGY DESCRIBED AS ABSORPTIVE.

The second thread in the absorptive strategy is the integration of military and commercial interests, which is primarily expressed via the PRC's Military-Civil Fusion (MCF) strategy. This initiative aims to remove barriers between China's industrial and defense sectors, ensuring the PLA has access to cutting-edge technologies developed by Chinese companies.

China's MCF strategy is complex, but it essentially attempts to blend commercial Chinese firms into the PLA's innovation ecosystem. While intellectual property (IP) theft gets most of the attention and press, MCF is an important part of China's absorptive strategy that should not be overlooked. As the Center for New American Security explained in a report titled *Myths & Realities of China's Military-Civil Fusion Strategy*, "Without an accurate understanding and communication of MCF as a strategy, American policymakers cannot square up to the competitive challenge."

We may also consider a third, academic, component of the PLA's absorptive posture based on reporting that "25% of U.S. STEM [Science, Technology, Engineering, Mathematics] graduate students are Chinese foreign nationals." According to Chinese government data, students are returning to China after graduation in greater numbers than in previous years. An Axios report noted that, while only 10% to 20% of Chinese undergraduate students returned to China after graduation in the early 2000s, "in 2017, around eight in 10 students chose to go back home." The report suggests this high rate of return is largely driven by a combination of incentives provided by the Chinese government (allowances, benefits, etc.), the U.S. government's antagonistic treatment of immigrants, and reduced quantities of student visas issued by the United States.

However, that report is based on data from China's Ministry of Education (MoE) regarding undergraduate students. The situation with graduate students in STEM fields tells a very different story. An issue brief from the Center for Security and Emerging Technology, based on data from the National Science Foundation, reported that "intention-to-stay rates were around 85 to 90 percent in 2017" for Chinese PhD candidates in most STEM fields. This is a stark difference from the numbers the MoE chose to highlight.

The fact that China's MoE emphasizes the high rate of return figures is itself an interesting data point, and may indicate more about China's priorities and aspirations then reality. Chinese graduate students in STEM fields appear to be more motivated to pursue careers outside of China, despite what the Chinese government might prefer and what anti-immigrant voices in the United States might claim. In fact, these data suggest the United States is the emigration *beneficiary* of highly skilled/highly educated individuals from China.

There is some evidence that this trend may be shifting. An August 2021 article in *Fortune* noted a reduction in the number of Chinese students *applying* to American universities: "Chinese student applications for the coming academic year shrank 18% compared with last year's cycle… The decline appears especially pronounced given that U.S. colleges got a 9% boost in applications from international students in this cycle."

Lower application rates combined with the fact that multiple rankings show Chinese universities making significant gains while U.S. universities decline may drive more technical talent to be educated in and remain in China. The Chinese government's claims about student return rates suggest a strong interest in leveraging this talent pipeline. While China's progress to date appears to be limited, the future may tell a different story.

Although the academia situation bears monitoring, the bulk of this paper focuses on the first two components of absorption: *adoption* and *integration.*

China's Longstanding Reliance on Foreign Technology

China has a long history of reliance on foreign technology. For example, in 1863, while the United States was in the middle of the Civil War, a Qing Dynasty official named Li Hongzhang said:

we should seize the opportunity … to make a substantial study of all kinds of foreign machines and weapons in order to learn their secret completely. … After the battalions at the capital have learned to use these superb and secret weapons, learning to make them can be extended.

Studying the secrets of foreign technology, first to learn how to use the technology and later to learn how to produce it domestically, continues to be a primary innovation strategy in China even today. According to "Why China Has Not Caught Up Yet," an article in MIT's *International Security* journal, "In 2007, 2009, and 2011, Chinese hackers entered the servers of the Pentagon and gained access to some fifty terabytes of data containing the designs and blueprints of U.S. stealth fighters, as well as other critical information."

It is worth noting that the United States is not the only target of China's attention. The PLA has made consistent efforts to copy military systems from Russia as well as other countries, often by purchasing a small quantity and reverse-engineering the design. Rostec, Russia's state-owned defense conglomerate, objected to this practice in 2019 and reported 500 cases of IP theft over the past 17 years.

CHINA HAS A LONG HISTORY OF RELIANCE ON FOREIGN TECHNOLOGY.

The PLA has also adopted a more overt, collaborative approach to technology transfer, such as its 2019 heavy-lift helicopter co-development effort with Russia. A Chinese official stated, "Our goal in the cooperation is to learn from Russia's strong points and close the gap." The Russians seem to find this collaborative approach a necessary step given Chinese military advances. As Vadim Kozyulin from the PIR Center explained, "It's becoming increasingly difficult to offer China anything new, so Russian policy is to move away from arms sales to joint development."

Understanding Military-Civil Fusion

[A] literal translation or even free translation of terms and phrases of this nature is insufficient to capture the full nuance. The political theories and historical context behind each term are crucial to understanding the meaning of the term.

– Military-Civil Fusion Terminology: A Reference Guide

MCF is a challenging topic for Westerners to understand, for several reasons. Along with the difficulties of translation and general unfamiliarity with Chinese thought, culture, and history, China's terminology and strategy related to MCF has changed over the years, sometimes emphasizing balance and other times placing a stronger emphasis on military needs and interests.

The current instantiation of MCF aims to increase the military's access to commercial technology while also boosting the broader economy. Toward that end, the PRC established MCF industrial zones across China, with a focus on "dual-use" innovation, such as shipbuilding and aviation. Chinese leaders saw "85% of technologies as having dual-use applications" and envisioned MCF as a mechanism to reduce redundancies, improve efficiency, and enable better government directing of resources.

While the MCF concept was developed in part to reduce the power of state-owned enterprises (SOEs), in MCF industrial zones SOEs now serve as innovation hubs to support a broader commercial and defense ecosystem. A prime example is the state-owned Commercial Aircraft Corporation of China, which strives to meld commercial and military aviation applications by leveraging the talents of private enterprises.

The DoD must be careful to not adopt a superficial or simplistic understanding of MCF. It should not assume that MCF is roughly equivalent to the American Civil-Military Integration efforts, as the two practices differ considerably. While the Pentagon generally aims to be a profitable business partner when cooperating with commercial companies, China's MCF tends to focus instead on coopting the civilian process and directly influencing corporate R&D investments. There is a big difference between using civil technology and fusing with civilian corporations.

At the same time, the DoD must also recognize that MCF is not simply a wholesale domination of China's industrial sector by the PLA. There is often a strong emphasis on balance and mutual benefit, seeking to ensure the PLA has sustainable access to the civil sector in a way that enables long-term collaboration. But even such terminology around balance and mutual benefits means different things in China versus in the United States.

Finally, it is important to note that, despite recent progress, the civil and military sectors in China are not as fused as they might appear. As *Myths and Realities of China's Military-Civil Fusion Strategy* observed, "The 'fusion' that MCF intends to create remains primarily aspirational … years of reforms and policy initiatives have had limited efficacy in reducing those barriers."

While the PLA's progress on MCF is limited, this initiative seems to be gaining traction and greater degrees of emphasis in recent years. A more detailed exploration of this topic is beyond the scope of this paper, but MCF as a topic on its own is worth further study. Air University's China Aerospace Studies Institute report *China's Military-Civil Fusion Strategy* is an outstanding place to start.

Maintaining a Viable Defense Industrial Base

Prior to the 2000s, China's defense industrial innovation model was primarily centered on funding many projects across all sectors to ensure a generally equal sharing of resources. In the 2000s, there was a concerted effort to inject more competition into the process, to focus resources on key priorities and to consolidate the many R&D institutes into the larger SOEs we know today. This is not dissimilar to the "Last Supper" that occurred with the U.S. Defense Industrial Base in 1993, when 107 firms condensed into roughly 5 major entities. While the U.S. situation was driven by reduced defense funding, Chinese SOE consolidation was driven by the need to improve effectiveness.

The establishment of major defense conglomerates is a feature of most modern countries. The primary difference between the U.S. and Chinese model, however, is that while the United States allows the market to naturally consolidate where it finds efficiencies (except in anti-trust cases), China has been actively promoting consolidation of state-owned firms. President Xi Jinping has even declared these large SOEs as "tech champions," with each focused on a core industry.

Many SOEs compete against one another very aggressively, and therefore should not be seen simply as government-controlled monopolies. The environment has some attributes in common with American-style capitalism. However, SOEs do often enjoy a more favored status in competition with the private sector. In a recent report, companies described instances in which private companies faced more significant challenges and were not able to compete fairly against SOEs. This may account for the fact that, as of 2019, Chinese

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experts estimated that only 2% of China's private high-tech enterprises were involved in defense work, and mainly in auxiliary roles.

Chinese SOEs do, however, employ numerous private companies in their projects, and they have recently become significantly more efficient and profitable, which helps ensure a strong defense industrial base. SOEs also provide China assurance that state resources are being used to pursue national strategic objectives. As part of recent reforms, SOEs were divided into "competitive sectors and strategic sectors," with the government able to direct resources as needed. China's central and local governments are also directing subsidies and benefits to

smaller and medium-sized companies that operate in "strategic" dual-use technology sectors. For example, in Shanghai's aerospace-focused Minhang National MCF Zone, there are over 1,700 companies designated as "high-tech enterprises."

The United States also maintains a strong defense industrial base with highly profitable, large prime contractors that engage with numerous smaller businesses (Figure 1). While it is unable to be as directive with its major primes as Chinese officials are with SOEs, the United States does employ more subtle government mechanisms to influence behavior. For example, it allows only certain costs to be reimbursed on a contract or as part of an industrial overhead rate. This includes an allowance for government reimbursement of independent research and development projects provided they meet certain national security objectives.

While there are some similarities in how the collective national governments influence their industrial bases, the Chinese model, despite reforms, is more deliberate in its approach while the United States honors the market-based model but also retains some levers of influence.

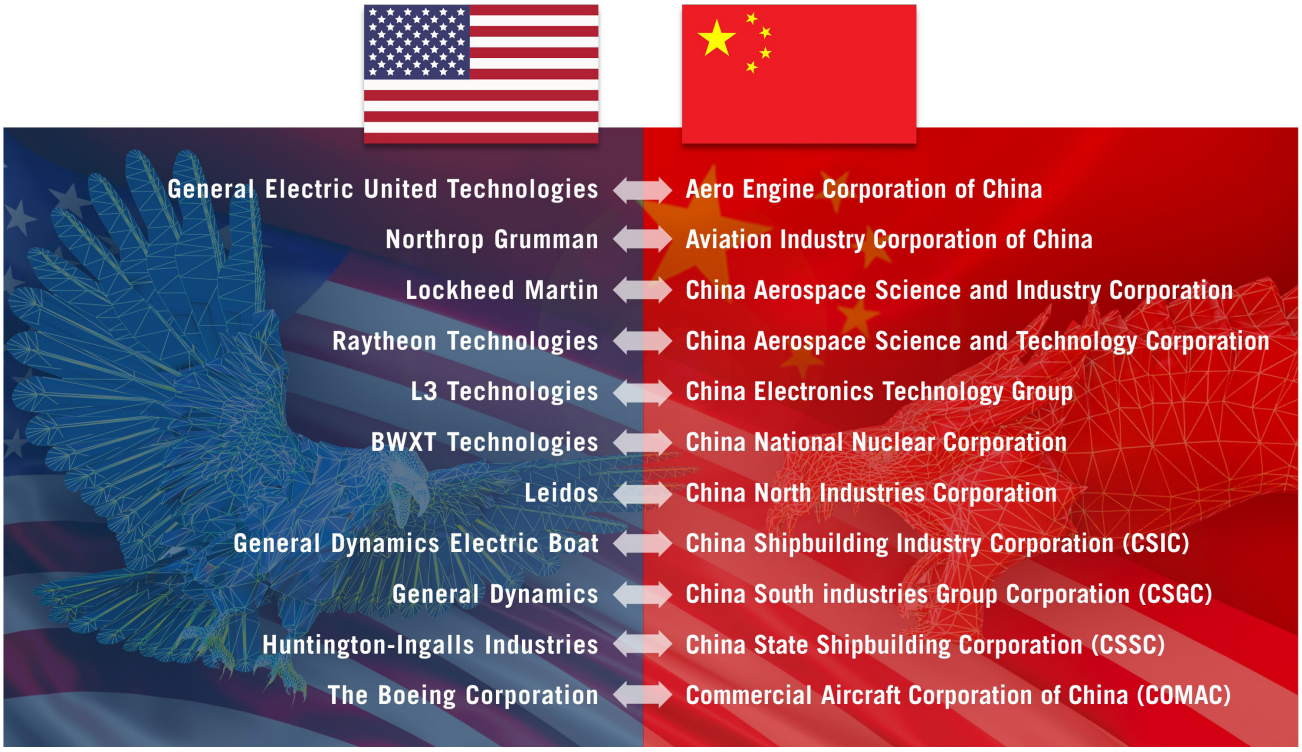

Figure 1: United States and China Defense Industry Corollaries

Translating R&D Into Military Solutions

Deepen the collaborative innovation of military and civilian science and technology, strengthen the coordinated development … and promote the two-way transformation and application of military and civilian scientific research results and the development of key industries.

– China's Draft 14th Five-Year Plan and the Outline of the Vision for 2035

China clearly views its science and technology (S&T) enterprises as core to achieving its national economic and military goals. This is indicated in its strategy and vision statements as well by its increased S&T investments (Figure 2), which are expected to increase by at least 7% each year. Chinese leaders also have unambiguous expectations that S&T investments should generate solutions around which new industries can be developed. In one recent strategy document, China emphasized the desired outcome as "strengthening technological innovation and conversion and industrialization of S&T achievements."

This is not a new goal for China. In its research and development plan, issued 12 years ago, China had stated that it wanted to establish "world-class research institutes and universities, and world-competitive industrial R&D centers" as part of a national innovation system. However, in recent years China has had some core challenges with its S&T system. Researchers were generating numerous low-quality and low-impact patents to meet organization goals but were spending only roughly 5% of R&D funds on basic research that has the greatest potential for producing significant breakthroughs.

China recently adopted a new policy to address these issues with new funding criteria, changes to the patent system, different reward mechanisms for researchers, and strong government emphasis on basic research. For instance, state rules were revamped to allow researchers "to take sabbaticals of up to six years to join industry or create their own start-ups," all while continuing to receive their previous salary and other benefits. Chinese leaders expect these rule changes and continued S&T investments to allow the PLA to "leapfrog" peer competitors. This approach has been included in China's overall innovation reform efforts, which are a mix between "fast following and skipping stages." This requires S&T leaders to engage in higher-risk but higher-payoff projects.

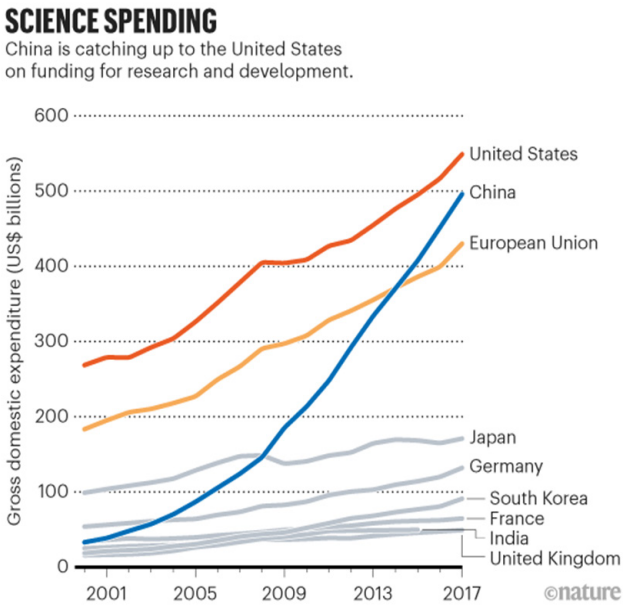

Figure 2: China's Increasing S&T Investments (from Nature)

These cultural shifts will likely require some time to become institutionalized. What can be ensured, however, is that in establishing this economic-oriented ecosystem, national security research goals will maintain some primacy.

China's State Administration of Science, Technology and Industry for National Defence (SASTIND) is a civilian agency that funds commercial and academic research in support of PLA requirements. SASTIND ensures that military-focused S&T investments are prioritized by issuing guidelines for grant applications that identify emerging technologies of interest to the Chinese military. In the latest issuance, there were 17 key tasks and 24 incubation areas identified with a granular level of specificity into what was needed from the research community to meet military objectives.

The universities that are viewed as integral to providing military advancements are sometimes labeled the "Seven Sons of National Defence," each with an area of specialization relevant to PLA objectives. The Seven Sons include Beijing Institute of Technology, Beihang University, Harbin Engineering University, Nanjing University of Aeronautics and Astronautics, Nanjing University of Science and Technology, Xi'an Technological University, and Northwestern Polytechnical University. However, as indicated in an excellent report from the China Aerospace Studies Institute, there is a much larger complex of laboratories that contribute to national defense goals through provision of foundational support; cross-sector innovation support; or the conduct of strategic, cutting-edge research.

One publication characterized the level of university-military integration as being so pronounced that it was more accurate to describe the Seven Sons as defense universities. This seems a fair characterization given that university scientists often "sit on PLA expert advisory committees and assist or even serve in major military projects," receive the majority of defense research prizes, and garner the most military technology patents. One Chinese journal noted that "more than half the academics at the Seven Sons have been involved in defence projects." China's largest defense SOEs also appear to view these universities as prime recruiting grounds, with six of the Seven Sons producing the most defense industry employees.

The United States also invests heavily in S&T but has seen investments at historically low levels in recent years. There is a similar trend with S&T funding focused on defense innovation. The fiscal year (FY) 2022 DoD S&T budget was over 5% less than the 2015 budget request when compared with total Research, Development, Test, and Evaluation (RDT&E) outlays. There are, however, various defense labs and defense agencies that tap into the university research complex, as evidenced by the available research funding opportunities that the DoD posts. The United States also has a complex of University Affiliated Research Centers (UARCs) that collaborate directly with defense researchers and develop cutting-edge military applications.

The primary differences between the U.S. and Chinese systems in how they pursue defense modernization with universities is integration, stability, and focus. China appears to have achieved better integration between the military and some of the largest and most technology-oriented universities in China. China possesses more stability due to increasingly elevated funding levels as well the consolidated controls provided by SASTIND. It also enjoys increased focus as a result of having clear leadership expectations combined with detailed S&T priorities that have a high probability of being funded. While this system does have weaknesses, there are some aspects that the United States should consider adopting.

Beyond Absorption

Just as the PLA's absorption strategy is about more than IP theft, its overall innovation strategy is more than absorptive. China is making progress on domestic development of new technologies and seems poised to increase the amount of original technology it creates. As Col George Dougherty explained in the September 2020 issue of *Joint Force Quarterly*, "Absorption, even theft, of foreign technologies has been part of its strategy, but is *only part of a much more complex picture*."

A 2018 research brief by the University of California Institute on Global Conflict and Cooperation observed that China has been "gradually expanding its focus towards more original higher-end innovation since the mid-2010s and this is likely to keep up pace in the coming years." A recent Whitehall 3-20 report from the Royal United Services Institute provided evidence of how China may be surpassing Russia in military technology development, noting that China is moving "from a position of dependency on Russian aircraft and weapons … [to developing] an advanced indigenous combat aircraft, sensor and weapons industry that is outstripping Russia's." The People's Liberation Army Air Force (PLAAF) is achieving this by rapidly iterating through designs of aircraft and other weapon systems, which is accelerating the pace of their improvements. As the same Whitehall 3-20 report noted:

the pace of iterative improvement visible in PLAAF equipment – from aircraft and weapons systems to increasingly realistic training and exercises – is striking.

… there are few areas of capability where the PLAAF is yet directly able to compete one-to-one with the best that the US and European air forces can field. However, if China can continue the level of investment, production and iteration demonstrated over the last decade, then existing capability gaps will close significantly, and more areas of outright Chinese advantage will emerge during the 2020s.

In addition to increasing its domestic technology development, China is seeking to evolve its absorption model in three ways:

1. **a greater role for market forces, although with the state still firmly in the driving seat;**
2. **greater attention to original innovation while still promoting absorption; and**
3. **a push for integration between the civilian and defense domains.**

These three reforms are clearly intended to be gradual and partial, rather than radical changes to the Chinese military's approach. The commercial sector's expanded role and the increased emphasis on domestic technology development is balanced by a government system that ensures the PLA's innovation and acquisition efforts will continue to be predominately state-led, absorptive, and military-centric.

Benefits of the Absorptive Strategy

In theory, the absorptive approach saves time and money on early phase development by leveraging the work of others. It reduces technical risk by relying on existing/proven technologies, rather than exploring new concepts that may lead to technological or operational dead-ends. Absorption also reduces the overall need for creative effort, substituting replication for the more difficult and less predictable work of imagination.

Using this approach, the PLA has achieved positive results in some mission areas. A 2021 DoD report on China's military developments stated, "China stands at, or near, the frontier of numerous advanced technologies. … The 14th Five-Year Plan maintains the PRC's focus on technological independence and indigenous innovation." In addition, "the Office of Naval Intelligence (ONI) has concluded that China has the largest navy in the world. … ONI projects that China will have 400 battle force ships by 2025 and 425 by 2030."

A thorough analysis of specific technical areas is beyond the scope of this paper, which simply observes that the PLA is making notable progress in several domains (e.g., artificial intelligence, hypersonics) using a combination of absorptive and generative strategies, with particular emphasis on current absorption and future generation. Interested readers may want to review the RAND Corporation's U.S.-China Military Scorecard, which provides a comparative analysis of the two militaries' capabilities in 10 operational areas, such as air superiority and cyber operations.

Limits and Costs of the Absorption Strategy

The absorption strategy faces several limiting factors, including the difficulty of replicating advanced technologies, a lack of access to tacit knowledge and related skills (such as program management and integration) that do not transfer as easily as blueprints, and limited opportunities to determine the direction of research and design. These limitations are among the reasons the PLA is increasing its generative activities.

The complexity and sophistication of modern systems make them difficult and expensive to copy, even by adversaries who have access to the technical designs and specifications. Producing advanced military weapon systems also requires strong program management, technical integration, precision machining, and other difficult-to-replicate skill sets that are not easily described in a technical schematic.

For example, China's J-20 fighter is clearly based on the U.S. Air Force's F-22 fighter, but it seems to be a weak copy with a relatively high price tag. As a 2019 paper from MIT observed:

The J-20 displays several design flaws and non-stealthy features … that dramatically increase its detectability to both radar and thermal sensors … a critical liability in air-to-air engagements with U.S. fifth-generation jet fighters. …

China has derived only limited cost and time advantages from its imitation efforts. According to Gabe Collins and Andrew Erickson, it is "reasonable to assume the J-20 has a unit cost of somewhere from US$100-to-$120 million. … By contrast, the F-22 costs around US$143 million per plane."

Maturation of the J-20 capabilities has not remained static, however, and "continues to rapidly mature and improve with the production of the J-20B variant." The expectation is that the "J-20 family will be produced in the hundreds over the coming decade, constituting the foremost existing aerial threat to Western air superiority types."

The J-20 story shows that the absorptive strategy may start with stolen designs or foreign technology, but it still requires iterative experimentation and domestic development. This means that, while the absorptive strategy's primary benefit is reduced costs in the early research and design phase, it still requires considerable investments and may save more money in theory than in practice. Despite its continued leverage of foreign technologies, China has had to make significant and increasing investments in its military. As the DoD's 2021 *Report to Congress on Military and Security Developments Involving the People's Republic of China* observed, "In 2021, the PRC announced its annual military budget would increase by 6.8 percent, continuing more than 20

years of annual defense spending increases and sustaining its position as the second-largest military spender in the world."

As further evidence of the limitations and costs of the absorptive strategy, Vasily Kashin, a senior fellow at the Institute of Far Eastern Studies of the Russian Academy of Sciences, offered a pragmatic Russian perspective on China's practice of reverse-engineering and duplicating Russian military systems:

Kashin added that Russia now feels Chinese reverse engineering is not all that threatening. He argued that even if Beijing successfully copies the arms, Russia will still retain its technological edge. "It's impossible to copy some technologies in a reasonable amount of time," Kashin said. "Copying old technology takes the same amount of time as developing new technology. It's much easier to take China's money, invest it in our own development, and let the Chinese do whatever they want."

Of course, the main limit of the absorptive strategy is that it cannot take the lead or push the envelope technologically. As RAND's 2021 report *Defense Acquisition in Russia and China* pointed out, "China's reliance on intellectual property theft means its weapons are years behind." At best, the absorptive approach can catch up or match the existing capabilities of its competitors. To go beyond that point, the absorber must pivot to a generative strategy, using the absorbed technology as a starting point for further developments and advances. The PLA is indeed adopting generative strategies in certain areas, but this requires a shift in behaviors, incentives, organizations, skills, and investments, all of which can be difficult, slow, and expensive changes to make.

Further, the absorptive posture puts the PLA into a position of technological dependency, where it must choose to either live with design decisions made by others, like when the DoD adopts Commercial Off The Shelf (COTS) products, or invest in modifications and redesigns of foreign systems, which adds costs and delays. This weak influence over the design of systems requires the PLA to accept requirement tradeoffs that may not align with its operational needs.

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The MCF strategy aims to address a portion of this external dependency by influencing Chinese commercial or dual-use products directly, but in doing so this introduces additional costs compared with a pure COTS purchase, further reducing the aspirational cost savings of the absorptive strategy.

Finally, even for the DoD, copying and replicating existing systems is harder than it looks, as the U.S. Air Force learned when it considered restarting the F-22 production line:

In 2011, the U.S. government interrupted production of the F-22. In 2017, the U.S. Air Force commissioned a study to understand how much it would cost to restart production. In other words, the United States wanted to know what it would take to copy its own technology from just six years before. … The findings are sobering: the same country that created the F-22 would have to spend $10 billion to restart the production of its fifth-generation fighter—equivalent to 25 percent of the total procurement cost for 194 aircraft.

This highlights an important point: an absorptive strategy is not the same as an absorptive capacity. To effectively reproduce foreign technologies and designs, the absorbing country's workforce needs to have a large set of skills and resources that enable them to understand, replicate, and modify the foreign technology. As the sophistication, complexity, and interconnectedness of DoD systems increase, China's ability to effectively and efficiently reproduce American systems diminishes. As the article "Why China Has Not Caught Up Yet" explained:

To free ride on the R&D of a foreign country, a country … must possess an adequate absorptive capacity: material and nonmaterial capabilities such as laboratories, research centers, testing and production facilities, a skilled workforce, and a cumulative technological knowledge.

This seems to suggest that the absorptive strategy is more limited, expensive, slow, and challenging to implement than it might first appear to be. However, despite the difficulties, limitations, and expenses associated with this approach, the PLA also seems unlikely to change its strategy on a large scale any time soon.

As the 1995 report by the Stockholm International Peace Research Institute titled *China's Arms Acquisition From Abroad* noted:

For more than 150 years Chinese leaders have recognized the need for military modernization through the procurement and integration of foreign weapons and weapon technologies. … Deeply rooted values thus continue to place constraints on China's military modernization through foreign acquisitions.

Nearly 30 years after this report, the PLA continues to rely heavily on absorptive strategies, and is only now making some progress in exploring other approaches.

The J-20 Mighty Dragon's Engine

The J-20 Mighty Dragon is the PLAAF's domestically manufactured stealth fighter, largely based on stolen designs of the American F-22 Raptor. Since jet engines are among the most difficult pieces of military technology to manufacture, China fitted the J-20 with AL-31F engines purchased directly from Russia instead of trying to produce the engines domestically. **This combination of IP theft and foreign purchases nicely illustrates a practical example of the PLA's absorptive strategy.**

The J-20's acquisition strategy shifted in 2021 when, as a condition of continued access to its AL-31F jet engines, Russia insisted China purchase additional SU-35 fighter jets. While the PLAAF wanted to purchase engines from Russia, it did not want the SU-35 jets, so it turned to a domestic engine program called the WS-10, which had been in development since the late 1980s. A January 2021 article in the *South China Morning Post* reported that the J-20's Russian engines would be removed and replaced with an upgraded version of the WS-10 called the WS-10C.

Due to a lack of manufacturing capabilities and tacit knowledge, building the WS-10C has proved to be predictably challenging. One anonymous inside source described the Chinese manufactured engine as "only as good as the Russian one," adding the decision to use it is "a stopgap choice." The article went on to note that "the WS-10C engine will not be fitted into the latest J-20B aircraft, which entered mass production in June last year, because testing is expected to take at least another year."

The domestically built WS-10C represents a step forward for China's domestic capability, and this achievement may set a foundation for further progress. This effort is inevitably **producing tacit knowledge that China should be able to apply to future engine projects.** However, it is worth noting that there is a marked difference between manufacturing a domestic engine that essentially copies and matches a Russian version and designing a domestic engine that performs better. The PLAAF seems to have done the former, not the latter.

Toward that end, the PLAAF has publicly stated its longer-term goal is to field a J-20 engine "matching the F119 engine used by the American F-22 Raptor." Meanwhile, the USAF announced plans to send 33 F-22s to the boneyard, essentially retiring aircraft whose performance the PLAAF has yet to equal. This reiterates one of the primary limits of a purely absorptive strategy—it can only follow, not lead.

This situation also highlights how **external dependencies can drive up costs and risks in an absorptive strategy**. The PLA was forced to decide between two undesirable choices: the excessive cost of purchasing SU-35s it didn't want, or the difficulty of learning to build a homegrown engine.

Xi Thought and Party Loyalty

China's larger political atmosphere has significant implications for the PLA's approach to acquisition and innovation. In broad terms, the PLA operates within an autocratic governance system that places a premium on compliance and conformity with the proclamations of a very small set of senior leaders. As a 2018 research brief by the University of California Institute on Global Conflict and Cooperation put it, "The Chinese defense innovation system is a heavily top-down, state-led undertaking, so development strategies and implementation plans drawn up by central military and defense authorities are carefully adhered to."

This is the result of the one-party government in general, and the increasingly autocratic leadership style of Xi Jinping in particular. The Institute for Security & Development Policy published an issue brief pointing out that "Xi's personality cult is manifested in every aspect of public life but also affects officials' behavior, creating a climate of insincerity and fear within the Party."

As one example of Xi's growing cult of personality, consider this policy statement found on China's Ministry of National Defense website, which highlights the importance of embracing "Xi Thought" and political loyalty across the military:

To strengthen China's national defense and military in the new era, it is imperative to comprehensively implement Xi Jinping's thinking on strengthening the military, thoroughly deliver on Xi Jinping's thinking on military strategy, continue to enhance the political loyalty of the armed forces, strengthen them through reform and technology, run them in accordance with the law, and focus on the capabilities to fight and win.

Xi's consolidation of power and autocratic approach is likely to undermine the type of creative thought necessary to achieve any type of innovation, in either an absorptive or generative strategy. For example, a 2021 joint research paper, *Reverse Innovation Transfer in Chinese MNCs*, by scholars from China, Sweden, and Italy in the *Journal of International Management* presented data showing that a multinational company's strong political ties tend to reduce the effectiveness of absorptive innovation strategies. As the article noted, "political ties … can be a liability as regards the international expansion and innovation augmentation of Chinese MNCs [multi-national corporations]."

The reason for this is not hard to imagine. Innovation requires the freedom to challenge conventional thinking and follow a novel concept in the direction the data leads, as well as the freedom to come up with entirely new concepts and proposals. If innovators are unable or unwilling to engage in the free exchange of ideas and instead are focused on demonstrating loyalty and maintaining strong political ties with an autocratic system, their ability to develop and deliver original ideas is severely curtailed. When senior leaders tightly control the system and discourage divergence from the party line or from the ideas and proposals of senior party officials, they impair the system's ability to deliver innovative results.

Innovation also requires a relatively high tolerance of failure. In a free market environment, high failure rates are generally recognized as the cost of doing business, or even as a sign of a healthy innovation ecosystem (consider the "fail fast, fail often" mantra adopted by many in Silicon Valley). In an autocratic environment, where developmental efforts are dictated by senior leaders whose judgment and competence cannot be criticized, a high failure rate

may undermine the credibility of the senior leader who directed these failed efforts in the first place. As Fareed Zakaria observed in a February 3, 2022, *Washington Post* article, "Beijing can operate with ruthless efficiency, which often makes Western democratic policymaking appear chaotic and second rate. But when a dictator's chosen policy needs to be changed, it is very hard for a dictatorship to correct course."

A desire to avoid failures and the corresponding difficulty of making course corrections leads to a reduced risk tolerance, a preference for making safer bets, an emphasis on predictability, and a tendency to hide failures, which further restricts learning. While nobody likes to fail, as Prof Kerry Brown from Kings College, London, wrote, "the fear of failure, and the consequences when failure happens, as it so often must, are very strong [in China]. And this is not a recent phenomenon, but one which lies deep in the cultural roots of China itself."

Taken together, this mix of autocratic control and fear of failure significantly reduces opportunities to learn and innovate. In areas where China is able to loosen controls, encourage diverse perspectives, and view failures as essential to learning, it will be able to improve its innovative capacity. However, this would be a significant departure from the predominant culture.

Of course, the DoD also exhibits tendencies toward top-down management styles and centralized authorities, a reluctance to delegate decisions, and an aversion to failure. However, in the United States these tendencies are openly criticized, often resisted, and regularly identified as barriers to innovation by leaders, writers, and practitioners. This is a stark contrast from the PLA, where those tendencies are admired and embraced—at least publicly. Aspiring innovators in the PLA thus face much larger barriers than do those in the DoD, and they are less likely to object to them.

There are some signs that China is making progress in this area, with some China watchers in 2017 reporting signs of "a gradual shift from heavy-handed top-down policy toward a more nimble, broad-based and less technology-driven approach." However, this shift is gradual, slow, and—like MCF—largely aspirational.

The "gradual shift" also runs against recent trends across China overall, such as the increasing emphasis on "Making 'Xi Thought' a guiding principle in every aspect of Chinese life." This has serious implications for China's innovation capacity, not only at the individual project or weapon system level but also in terms of how groups are trained, rewarded, and promoted.

For example, China's Thousand Talents Plan (TTP) provides awards and positions (not entirely defense related) to select individuals. While the intent of the TTP is to bring scientists to China, this remains a state-/party-sponsored approach to talent management, which surely leans toward selecting candidates who demonstrate an ideological commitment to Xi Thought. It is also almost entirely focused on selecting Chinese nationals—only 5% of TTP recruits were non-citizens. So, it is less about attracting scientific talent as it is about bringing back Chinese scientists, who are more likely to be ideologically aligned to the ruling party.

Many factors contribute to this low number of non-Chinese participants, and those factors also shape the overall low rate of immigration to China. As a 2019 article in *The Diplomat* reported, "China issued only 1,576 permanent residency cards in 2016. This was more than double what it had issued the previous year, but still roughly 750 times lower than the United States' 1.2 million."

As Charles Mann wrote in his book *1493*, China has long been interested in importing "foreign goods, not foreign people." This has significant implications for China's ability to innovate.

The American Acquisition Strategy Is Primarily Generative

The DoD likes to make new things. Strike that—the DoD loves to make new things. This is why so many of its investments, incentives, strategies, training materials, organizations, and acquisition methods are oriented toward the development of novel systems. Historically, the DoD has a strong track record of performing basic research that produces generational advancements such as radar, stealth, the internet, and GPS. American systems are occasionally copied or purchased from other nations, but the DoD follows this path rarely and reluctantly.

Thus, we describe the DoD's acquisition strategy as generative. This approach is primarily focused on domestic development of new technologies and seeks to generate original military systems that are designed to outperform those used by other countries.

While the DoD's acquisition challenges are widely reported and appropriately criticized, the U.S. military is nevertheless widely recognized as the "best equipped in the world." This assessment is occasionally amended with "in spite of the shortcomings in the acquisition processes," but the point still stands. As further evidence of the superlative state of American military technology, one might reflect on how much effort the PLA puts into stealing, copying, and imitating DoD systems.

A 2018 research brief from the University of California Institute on Global Conflict and Cooperation's Study of Innovation and Technology in China (SITC) project titled *The Very Healthy US Defense Innovation System* offered an interesting explanation for this situation:

The US defense innovation system enjoys tremendous advantages that other countries cannot readily replicate. It has accumulated capabilities over decades of funding and experimentation that dwarf other countries' efforts, and the incentives to innovate in the United States are not easily replicable elsewhere. The unique US political system favors substitution of technology for labor, openness to new ideas, and competition among decentralized organizations to solve national security challenges.

That report went on to identify two specific factors that contribute to creating and sustaining a strong innovation economy: Government-Funded Research Centers and immigrants:

Federally Funded Research and Development Centers (FFRDCs) or University Affiliated Research Centers (UARCs) … play a vital role … cultivating multiple design-team philosophies that enable diverse approaches to technological challenges, and using their independence to prevent the capture of the US R&D effort by the pecuniary biases of government customers and private-sector suppliers.

US military power benefits from immigration, a continuing source of new ideas and great energy.

Parts of the *Very Healthy* report may sound a bit naïve, but its description of America's innovation-friendly culture is difficult to dismiss. American culture does indeed "favor substitution of technology for labor, openness to new ideas, and competition among decentralized organizations to solve national security challenges." And certainly, the positive impact of immigration is hard to overstate. Consider, for example, this observation from a 2019 article in *The Diplomat*: "Nearly half of recent American Nobel prizes in STEM fields were won by immigrants, and immigrants also founded more than half of the country's highest-value technology companies."

Without immigrants, the number of American Nobel winners and big tech companies would be cut by half—or more. Of course, this does not refer to only immigrants from China. As an article from the *Berkley Political Review* observed:

Every nation, to different degrees, is losing talent to the U.S. while having difficulty retaining its own talent. Yet the most important and dramatic trend is between the U.S. and China. Historically, the entire technology human capital market has been typified by one trend: that of a massive "brain drain" from China to the U.S.

The benefit of all this immigration applies to the entire country and is not exclusive to the DoD. The fact that the DoD does not aim to monopolize STEM talent helps ensure the larger innovation ecosystem is growing and healthy, creating opportunities that benefit the DoD directly and indirectly. It is likely that a strictly defense-focused approach, such as China's MCF, would provide fewer advantages.

The field of artificial intelligence (AI) offers a particularly relevant data point on this topic. As the Macro Polo Global AI Talent Tracker observed, more than 81% of Chinese AI PhD students go on to work in the United States after completing graduate school in the United States. The Talent Tracker website also noted:

1. **China is the largest source of top-tier researchers, with 29% of these researchers having received undergraduate degrees in China. But the majority of those Chinese researchers (56%) go on to study, work, and live in the United States.**
2. **Over half (53%) of all the top-tier AI researchers are immigrants or foreign nationals currently working in a different country from where they received their undergraduate degrees.**

Taken all together, this suggests that the United States in general, and the DoD in particular, manages to regularly provide significant incentives and enablers of innovation. The U.S. military benefits tremendously from a deep and well-established bench of supportive infrastructure, a culture of openness to new ideas, and a committed belief in the value of creating new things across the entire country. Each of these advantages is tightly coupled with a persistent level of dissatisfaction and a desire to improve the infrastructure, culture, and so on. On that note, the Very Healthy report offered an interesting theory: "the constant worrying that the United States is losing its defense innovation advantages is simply part of the politics that keep the United States far, far ahead of its potential rivals."

As if to prove that point, the National Defense Industrial Association's *Vital Signs 2022* report offered a more pessimistic assessment and gave "a final grade of 'Unsatisfactory, Failing' for the health and readiness of the defense industrial base." However, the report went on to say, "Despite numerous negative scores, areas of confidence give cause for optimism within the defense industrial base," citing demand and competition as particular areas of strength.

While the *Vital Signs* report correctly calls out some areas of concern, the systemic elements of openness, immigration, self-criticism, and dissatisfaction with the status quo are strong enablers of generative innovation. Indeed, the DoD's deep and consistent dissatisfaction with its own progress in these areas further reinforces the point about its cultural preferences and helps provide forward momentum.

More Than Just Generative

Creating entirely new technologies, capabilities, and systems is closely associated with the term *innovation* in popular usage, but it would be a mistake to assume that generative strategies are the only way to produce true innovation or that the DoD's approach is purely generative. In fact, the absorptive practice of putting mature technologies together in new ways is a very common method for developing new systems, even in the DoD.

The DoD uses absorptive strategies in a different way than does China. Instead of fusing commercial companies with military interests, purchasing foreign technologies, or stealing intellectual property, the DoD's absorptive methods tend to take the form of integrating commercial technology into military systems.

Individual examples of the DoD's absorptive strategy include the PlayStation-based Condor Cluster supercomputer, integration of iPads in military cockpits, the Virginia Class Submarine's use of Xbox controllers, and the use of Amazon Web Services for cloud computing. While the DoD is increasing its reliance on commercial technologies, it is worth noting that this is a point of concern for some in the defense technology realm. They bemoan the fact that the DoD is no longer the prime driver or prime funder of technical innovations and R&D efforts. It bears repeating: the DoD loves to build new things, and seems to find satisfaction and security in doing this work in-house (or with dedicated defense contractors). Purchasing and using commercial products from non-traditional vendors is still viewed skeptically in certain circles.

Nevertheless, the DoD is making good and important progress in this area. At the service level, USAF Major and Director/Co-founder of AFVentures Dr Jason Rathje described AFVentures' commercial collaboration this way:

The Air Force's Commercial Investment Group [AFVentures], which started as a $10M experiment in 2018, has now reached over $1B in funds under management, becoming a mainstay in the dual-use economy.

Over that time, the AFVentures and #afwerx team has worked with ~1,800 companies, over 75% new to the Air Force, who in turn tripled the number of "technology transitions" for the Department.

And #venturecapital has responded in kind, with the AFVentures portfolio now representing over 80% of all private equity invested in DoD SBIR companies. Total ROI is nearly $11:1, with growth doubling year-over-year, making AFVentures one of the most successful "funds" in the country.

Beyond the individual service level, the Defense Innovation Unit (DIU) is a DoD-level entity that is focused on "accelerating the adoption of commercial technology throughout the Services, Combatant Commands (CCMDs), defense agencies, and other components. … DIU also provides thought leadership in the commercial, dual-use technology space." DUI's *2021 Annual Report* offered this summary of its recent activities:

- **Published 26 solicitations for commercial solutions, a 4% increase from the prior FY.**
- **Received a total of 1,116 company proposals, a 10% uptick from FY 2020. We saw an average of 43 proposals per solicitation, with the highest number of commercial proposals received in response to a single solicitation rising from 111 in FY 2020 to 153 in FY 2021.**
- **Issued 72 prototype Other Transaction (OT) contracts to commercial companies, a 31% increase from FY 2020.**

These examples show how the DoD is reaching out to partner with commercial companies that are not primarily or traditionally involved in defense work, and creating pathways for the DoD to adopt commercial tech. These initiatives show great promise and should continue to be supported and expanded in the years to come. The House Armed Services Committee made much the same point in 2020, when it recommended a 10-fold increase in DIU's budget. Unfortunately, DIU ended up with a 20% budget cut instead, so clearly more work needs to be done.

However, the United States is not alone in shifting more focus to the commercial sector. As a DIU study found, China was involved in approximately 16% of all venture capital deals in 2015, which represented the start of a growth trend. While China has been historically restrictive with foreign involvement in certain areas (there are prohibited lists, for instance), the U.S. economy has been much more open to foreign capital. This has led to China gaining expertise by financing U.S. early-stage technology companies in areas where it knew it had weaknesses and that were critical for meeting its future military and economic goals.

In recent years, the United States has used the powers of the Committee on Foreign Investment in the United States more frequently to limit the ability of foreign competitors to advance their goals. The United States should continue to exercise these powers to minimize the compromise of national security while also continuing to encourage direct foreign investment.

Benefits of Generative Strategy

The DoD's primarily generative approach to innovation and acquisition creates the possibility of technological overmatch (as described in 2017 National Security Strategy), where Blue forces can significantly outperform Red forces and where the United States' overall posture provides a strong deterrent to acts of hostility.

This persistent investment into R&D also creates new domestic economic opportunities across the country, further strengthening both the operational force posture and the corporate innovation economy, creating a virtuous cycle. Finally, an emphasis on generating new technologies and systems helps to set the pace that absorptive adversaries must follow.

The development of increasingly sophisticated (and complex) systems has a particular benefit when competing with an absorptive adversary: it makes imitation extremely challenging. As the article "Why China Has Not Caught Up Yet" noted, "This increase in complexity … has made the imitation and replication of the performance of state-of-the-art weapon systems harder—so much so as to offset the diffusing effects of globalization and advances in communications."

An important aspect of the generative strategy that often gets overlooked is the iterative nature of the design process. No matter what the DoD's acquisition process diagrams may suggest, a new military system is almost never the result of a single, linear process. Rather, the path to developing a new system inevitably includes a series of false starts, dead-ends, go-backs, and other excursions whose stories are seldom told and whose contribution and value are often dismissed as "waste." The path also often involves continued upgrades and modifications throughout a system's lifespan that provide new capabilities.

This iterative approach to generating new systems means that for any given program, the design team did not simply make one system in a single attempt. Instead, the team made multiple systems, multiple times, and along the way it produced specialized tacit knowledge that is generally not codified or documented anywhere.

The value of this tacit knowledge is easy to overlook because its contributions tend to be subtle and obscure. However, studies show that "tacit

knowledge is an important driver in the innovation process," and accounts for much of the sense that innovation is "magic."

The key point on this topic is that the DoD's generative approach produces a type of knowledge that is difficult for an absorptive competitor like the PLA to transfer to its own workforce, even when it has access to documentation and physical artifacts. By the nature of how it is produced and where it is stored, tacit knowledge cannot be directly stolen or copied. It can only be earned. And because it tends to be domain specific, tacit knowledge provides generative initiatives a certain degree of defense against an absorptive adversary.

It should also be noted that while tacit knowledge cannot be copied, it can be lost through workforce turnover, attrition, or a lack of collaboration and mentoring. Leaders should thus make a concerted effort to develop and maintain this essential form of information within their workforce.

Limits and Costs of the Generative Strategy

Generally speaking, it costs more and takes longer to develop new technologies from scratch than to copy or purchase existing technologies from other countries. This approach also requires a relatively high tolerance for failure and a certain amount of waste, as dead-end programs must be terminated prior to delivering fieldable capabilities.

The DoD has historically been very risk averse in its approach to technology development. There is a strong culture tendency to predict, in great detail, all the risks that will be realized and baseline a plan prior to any design details being affirmed or any production completed. This predictive approach that requires cost, schedule, and performance goals be ironed out in advance is a major flaw in the DoD's generative approach. As Nicholas Drake explained in an article for *Real Clear Defense* written while he was a student at the Army's Command and General Staff College:

Leaders in the national security community must remedy the incapacitating risk aversion which has permeated both the civilian and military ranks of the defense establishment if they are to successfully respond to the inherent uncertainty of future conflicts. Risk aversion stifles creativity, cedes the initiative to our adversaries, and presents a real, significant, and imminent threat to American national security.

Crossing the proverbial "valley of death" is also a persistent challenge in a generative system, because the emphasis tends to be on creating new things, while integration into operations (to say nothing of sustainment and logistics considerations) is often considered relatively late in the process. Prototypes and demonstration systems may show considerable promise in early phases, but the time it takes to transition from concept to fieldable capability is often frustratingly long.

This cost can be significantly reduced if programs are developed in closer partnership with operators from the start, and if acquisition plans include more explicit considerations of activities such as integration, fielding, sustainment, and logistics earlier in the design process. However, despite frequent recommendations to be more risk tolerant, integrate users more frequently, and focus on tech transition, the DoD's generative posture remains largely resistant to such changes.

Assessing Risks of the Absorptive/Generative Scenario

If we sit back and don't react, we will lose our technological superiority in 2020.

– Vice Chief of Staff Gen Paul Selva

The current competitive scenario between the United States and China can be described as an absorptive/generative scenario. These terms refer to the predominant strategy for each side, although as mentioned previously (and as Figure 3 shows), neither is purely absorptive or generative. In both strategies, the relative amount of each activity is evolving over time, with the PLA increasing its investment in domestic R&D and the DoD increasing its investment in adopting commercial systems.

Figure 3: Comparison of Acquisition Postures

In the absorptive/generative scenario, the United States faces two primary risks:

- **Risk 1: Replication:** An adversary gets access to DoD system specifications and *replicates the technology*, reducing the DoD's tech overmatch.
- **Risk 2: Exploitation:** An adversary gets access to DoD system specifications and *identifies vulnerabilities* they can exploit.

A thorough risk assessment is beyond the scope of this paper, but some preliminary comments should provide notional boundaries of where the risk may reside and what steps the DoD might take to mitigate them.

The two dimensions of risk, *likelihood and consequence*, are typically mapped out using a Risk Reporting Matrix, as shown in Figure 4. We may start by observing that the likelihood of the PLA getting access to detailed technical specifications and other intellectual property related to DoD systems is high, perhaps close to a certainty. China regularly demonstrates it possesses the will and capability to access such information, so for a significant percentage of DoD systems, this is essentially a question of when, not if, the PLA gets access to technical data. The DoD should take appropriate actions to safeguard information about military systems, but it should also not be surprised when the PLA gets a copy.

However, the actual risk is not whether the PLA will access classified technical details about DoD systems, but rather what the PLA will do with that information. Compared with the risk of accessing data, the likelihood of effectively *replicating* DoD systems based on stolen blueprints is much lower (see Figure 4), as explained earlier in this paper.

This matters more. Simply having access to blueprints and related specifications (or even hardware for the purpose of reverse engineering) does not automatically mean that replicating the technology will be easy, affordable, or even possible, as experience with the J-20 fighter jet and various systems based on Russian technology demonstrates.

The second dimension of the risk matrix, *consequence*, is more challenging to determine because the analysis needs to consider questions

of how well the PLA's replication matches U.S. capabilities and in what quantities these copies can be produced. A more nuanced assessment might involve comparing the relative risk of two scenarios, as shown in Figure 5:

1. **Upper Left:** The PLA produces a weak copy of an American system. This is more likely and less consequential than if it produced a strong copy.
2. **Lower Right:** The PLA produces a strong copy of an American system. This is less likely and more consequential than if it produced a weak copy.

Scale is an important contributing factor to this risk item, and the consequence is directly influenced by the quantity of copied systems. If the PLA produces only a small number of copies, the consequence is likely to be reduced, even if the copies are strong. As the number of copies scales up, the consequence increases, even if the copies are relatively weak.

Finally, the diversity of the DoD's arsenal has a significant impact on the risk calculation. Where the DoD is developing a single program for a particular mission area, the likelihood and consequence of IP theft is relatively high. That is, a single target is easier for the PLA to go after (which increases *likelihood*) and the DoD's reliance on that singular system makes a compromise of that single system more consequential.

However, where the DoD is developing a portfolio of programs for a particular mission area, the likelihood and consequence of IP theft are both reduced, as shown in Figure 6. This is because more systems equals more targets for the PLA to chase (which reduces likelihood the PLA will successfully target any given system), and a diverse portfolio creates greater agility and resilience on the DoD's side (which reduces our dependence and therefore the consequence of any given system's compromise).

Thus, this risk assessment is heavily reliant on the diversity of the DoD's development efforts. In some mission areas, the DoD is developing multiple types of technologies (e.g., Uncrewed Aircraft Systems) and faces less risk, while in other mission areas the DoD relies on a single technical system (e.g., F-35), which faces greater risks in an absorptive/generative scenario.

For the second risk item—using technical specifications to *identify and exploit vulnerabilities*—the likelihood and consequence of this scenario will vary depending on the technology in question. This risk assessment is likely to require a classified level of analysis that goes beyond the scope of this report, so it is mentioned here only for completeness and as a suggestion for future research.

As the PLA increases its use of generative strategies, this risk assessment will need to be updated.

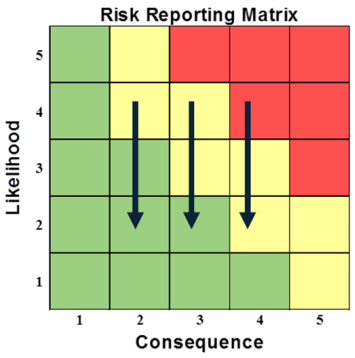

Figure 4: Likelihood of China Effectively Replicating DoD Systems

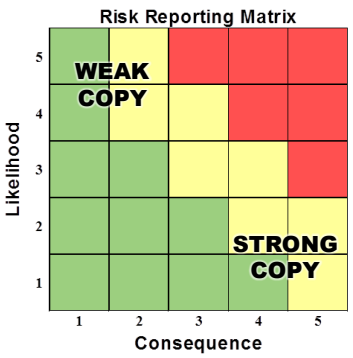

Figure 5: Relative Risks of Strong and Weak Copies Systems

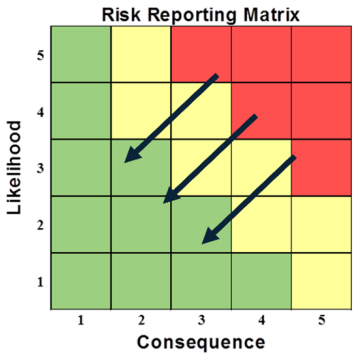

Figure 6: Portfolio Management Reduces Overall Risk

Recommended Strategies

[The United States] needs to consider new strategies to prevent American know-how from inadvertently powering China's technological advancements.

– We Spent a Year Investigating What the Chinese Army Is Buying

The preceding analysis aims to increase the DoD's understanding of its current competitive environment. However, the primary goal of this paper is to recommend strategies the DoD can adopt to minimize the effectiveness of the PLA's absorptive strategy and drive increased costs, delays, and difficulties into the PLA's innovation and acquisition system.

Recommendation 1: Cultivate Strategic Empathy

In order to successfully deter or otherwise coerce the PRC, defense and security officials must understand the PRC's views of its values and interests, strategy and policies, risk tolerance, capacities and capabilities to adapt and respond, and its decision-making processes.

– You Cannot Think Like a Westerner

To beat your opponent, you must truly understand how they view the game. Thus, the first step in countering the PLA's innovation strategy is to understand it in a detailed, nuanced way. The DoD acquisition community should make a point to cultivate *strategic empathy*, which author Kathleen McInnis described as "meaningful understanding of the other" in a piece she wrote about military strategy. McInnis explained this is the opposite of *strategic narcissism*, which is focused on manipulation rather than genuine understanding.

Cultivating strategic empathy would help the DoD's acquisition community move beyond a superficial view of China's approach to acquisition and innovation, and establish a more complete and accurate picture of the PLA's innovation posture. Specifically, the DoD needs to understand that the PLA's absorptive approach is not just about IP theft and that MCF is more complex than a wholesale domination of the industrial sector by the defense sector. The DoD must also recognize how this all fits into the larger strategic and political environment, first to understand the advantages and gains China seeks to secure for itself, and then to identify ways to minimize those gains.

As the DoD studies China's strategy, it must particularly avoid falling for misleading, inaccurate, and racist stereotypes that suggest the Chinese people are not creative or capable of genuine innovation. It is equally important to not treat China as a boogieman, and to neither overstate nor underestimate China's threat, capacity, or hostile intent. While China is clearly a competitor, actual conflict is neither inevitable nor desirable. As Pentagon Press Secretary John Kirby said in 2021, "Competition does not necessarily have to mean conflict and we're not chasing conflict. In fact, we'd like nothing more than to be able to deter any conflict or miscalculation."

The DoD should also be careful to not be envious of China's supposed efficiencies and end up tempted to adopt a centrally controlled, top-down approach to innovation that mirror's the PLA's posture. The goal should be to work toward improving our understanding of what China wants, how it is likely to go about pursuing those wants, and what the implications, risks, and opportunities are for the United States.

Recommendation 2: Be a Better Customer/Business Partner

To counter the PRC's investments in foreign companies, the DoD should aim to be a better business partner than the PLA and a more appealing ally than China, particularly for small businesses and innovative start-ups in the United States and around the world, and also for innovative companies of all sizes.

The DoD should increase its efforts to connect promising companies with capital providers, building on the work currently underway with organizations like DIU, AFVentures or Trusted Capital, as well as other mechanisms still to be developed. These efforts would help strengthen the DoD's connections with the American defense industrial base, establishing the DoD as a more accessible customer than it has been in recent years. As one positive example, in early 2022, Special Operations Command awarded a $1 billion contract to Anduril, which author Bill Greenwalt said "sends a signal that startups and non-traditional companies can actually succeed in the federal marketplace."

While these examples show signs of progress, much work remains to be done to remove barriers to participation and increase the diversity of the industrial base, which is currently dominated by a small number of prime contractors. According to a 2022 Government Accountability Office report, between FY2011 and FY2020 the number of small businesses receiving contracts from the DoD decreased by 43%, as shown in Figure 7.

At the 2021 Reagan National Defense Forum, Secretary of Defense Lloyd Austin commented on this trend, saying, "For far too long, it's been far too hard for innovators and entrepreneurs to work with the department. The barriers for entry … to work with us in national security are often too steep — far too steep."

His comment adds considerable weight to this particular recommendation. The GAO's *2021 Small Business Contracting* report offers several specific courses of action that the DoD should evaluate and adopt. In general, to be a better business partner with innovative companies and early start-ups, the DoD needs to provide three things to industry:

1. A shorter, faster, and simpler path for small companies to secure substantial funding
2. A better ear to listen to industry's concerns, priorities, barriers, and ideas
3. More clarity and insight to help non-traditional vendors understand the DoD's operational needs (such as the USAF/MassChallenge collaboration program)

One concrete way to broaden the industrial base is to launch a "First Breakfast" initiative, to counter the effects of the so-called Last Supper from 1993. This would involve deliberate outreach to innovative start-ups and small businesses, which do not currently do business with the DoD but whose technology might have defense applications. Steps such as these would not only increase the DoD's access to advanced technology but also reduce the incentive for Wall Street and tech firms to pursue profits in China.

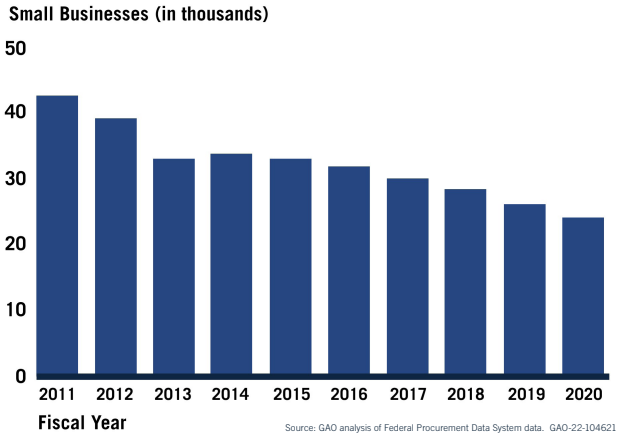

Figure 7: Number of Small Businesses That Received Contract Awards From the Department of Defense, Fiscal Years 2011–2020

In addition to preventing the PLA from having access to American/Western technologies and systems, broadening the defense base also expands the DoD's overall generative infrastructure. This involves cultivating domestic production capabilities and producing tacit knowledge (e.g., precision manufacturing of jet engines), which is difficult to steal or imitate.

Recommendation 3: Increase Use of Portfolio Management (and cancel more projects)

> **Instead of spending years defining detailed program requirements that are nearly guaranteed to be wrong, DoD leaders should capture enduring portfolio level requirements and measures.**
>
> – Bad Idea: Managing Defense Requirements, Budgets, and Acquisitions via Programs

As the risk discussion showed, large, single projects are relatively easy targets for an absorptive adversary to identify, pursue, and copy. In contrast, a portfolio of diverse projects, in which only a subset transition to operational capabilities, is less risky for the DoD and presents the PLA with an unpredictable set of technologies to assess, driving costs, delays, and difficulties onto its balance sheet.

Early in the lifecycle of a portfolio, there is no way for *anyone* to know which programs will proceed through to completion. A portfolio approach therefore presents an absorptive adversary with a range of unpalatable options, such as:

1. Duplicate the entire portfolio (including programs that will be terminated).
2. Duplicate a subset of the portfolio (and hope they guess correctly).
3. Wait until the DoD makes its decisions and then copy the winners.

Option 1 is the most expensive and greatly minimizes any financial advantage the fast-follower approach might convey, because the PLA must replicate a significant portion of the DoD's investments, including technologies and systems that will end up getting terminated. Option 2 is the riskiest, as the PLA is likely to invest in dead-end technologies or inferior alternatives to what the DoD selects, an outcome the absorptive strategy explicitly aims to avoid. Option 3 is the slowest approach because the PLA must wait until the DoD makes its selections, thus delaying its ability to analyze and replicate the system.

The PLA may adopt a fourth hybrid strategy, perhaps stealing the IP for the entire portfolio, then performing limited analysis and preparation until the DoD selects which programs within the portfolio will actually get fielded. This is likely the most efficient strategy for the PLA to adopt, but nevertheless the portfolio approach makes the absorptive strategy more expensive and slower for the PLA than if the DoD were building a single system.

The good news is that portfolio management is highly efficient and economical. As Nobel Prize winner Harry Markowitz explained in his *Modern Portfolio Theory* work, a diverse portfolio of small programs is the optimal way to maximize the portfolio's return for a given level of risk. The key is to calculate risk and return on a *portfolio* basis, rather than on the basis of individual programs.

This portfolio approach is also wholly consistent with the organizational preferences and values of a generative organization like the DoD, which is already oriented toward creating new programs. However, this approach also comes with a certain level of difficulty, as former Secretary of the Navy Richard Danzig observed in the 2011 paper *Driving in the Dark:*

Starting more programs than can be sustained, comparing them side by side, killing the ones that are least cost-effective and allowing only survival of the fittest. This approach is anathema for central planners. … It requires starting more ventures than can be completed and, therefore, ensures the failure of some ventures (which will be described as waste).

Danzig acknowledged that the competitive approach he described is challenging for the DoD, in large part because this would "compel senior decisionmakers to judge and label failure." Despite the difficulty, the advantages are significant, and in the context of an absorptive/generative scenario, portfolio management drives even greater difficulties into the PLA's side of the ledger. As an added bonus, the PLA is likely to find that this a highly unpalatable strategy to copy, given its even greater reliance on central planning and its accompanying difficulties with making course corrections.

One other aspect of portfolio management that is worth mentioning is the importance of integration and interfaces. While individual projects may attract the most attention, the ability for systems to operate together is the real force multiplier. Thus, a portfolio of projects should place a premium on well-defined interfaces, modular structures, and other design decisions to ensure that each system plays well with others and fits seamlessly into the larger operational environment.

Recommendation 4: Operate at "Bewildering Velocity"

In any sort of speed-based competition, the easiest pace to match is a slow pace. Thus, the DoD can increase the PLA's difficulties and address the "pacing challenge of China" by going faster. This involves making rapid investments in a diverse portfolio of new technologies (see Recommendation 3), to produce an unpredictable stream of fieldable prototypes.

ACQUISITION STRATEGIES BASED ON A PATTERN OF QUICKLY ADOPTING AND ABANDONING TECHNOLOGIES WOULD KEEP THE ABSORPTIVE ADVERSARY OFF BALANCE AND MAKE ITS ABSORPTIVE STRATEGY MORE EXPENSIVE, SLOWER, AND LESS PRODUCTIVE.

The Air Force Chief of Staff's *Accelerate Change or Lose* paper provides strategic guidance on the importance of going faster at the service level. This guidance should be embraced, expanded, and implemented across all the Services, with particular emphasis on accelerating acquisitions. As one example, the *Accelerate* paper calls out decisiveness as a skill to be studied, learned, and mastered. Accordingly, the DoD should place particular emphasis on training the acquisition workforce in the skill of decisiveness—that is, the ability to make good decisions quickly.

In terms of policy, the recently established Middle Tier of Acquisition (MTA) pathway provides a repeatable and field-tested way for program offices and Program Executive Officers to accelerate delivery of new systems. A recent audit report by the DoD's Inspector General found that programs using the MTA pathway performed well and produced positive results, which strengthens the case for using that particular acquisition approach.

The "Bewildering Velocity" recommendation goes beyond simply accelerating the development timeline

for individual projects, programs, and portfolios or using a particular acquisition pathway. It also involves frequent changes in direction—thus the reference to velocity rather than speed. The DoD's acquisition system is currently based on the premise that most weapons will have a long service life, which creates a very predictable and inflexible defense posture, as well as a big reward for IP theft.

In contrast, acquisition strategies based on a pattern of quickly adopting and abandoning technologies would keep the absorptive adversary off balance and make its absorptive strategy more expensive, slower, and less productive. Transitioning to new technologies on a regular basis does come with costs, but those costs need to be compared to the potentially high cost of relying on older technologies that no longer convey a technological advantage because an absorptive adversary like the PLA has analyzed, exploited, and replicated them.

Recommendation 5: Reduce Benefits of Copied Systems

The acquisition community must continue taking cybersecurity seriously and make serious efforts to protect technical details and design specifications from theft. However, past experience suggests that the DoD cannot rely on preventing all cases of IP theft and reverse engineering. It must also explore ways to make stolen IP less valuable in the first place.

- **Build for the short term.** This prevents the DoD from getting locked into outdated equipment (see Recommendations 3 and 4), and makes it harder for an absorptive adversary to genuinely catch up. By the time the PLA has studied, understood, and replicated the technology, the DoD will have already moved on to the next item. This drives additional costs and delays onto the absorber's side.
- **Build complex systems.** While simplicity is a desirable attribute in many dimensions, complexity seems to convey an advantage in competition with an absorptive adversary, because complex systems are more difficult to analyze and replicate. The acquisition community should proceed with caution on this point, as excessive levels of complexity can significantly increase costs, extend schedules, and reduce availability, utility, and maintainability, among other downsides. However, a thoughtful approach to highly complex systems may convey a competitive advantage.
- **Prioritize adaptability.** This recommendation not only increases the flexibility of DoD systems in any environment, it also makes our force posture more resilient to absorptive adversaries in an absorptive/generative environment. Consider this observation from Richard Danzig's *Driving in the Dark* paper: "the B-52 is an airplane with high inherent resilience; essentially a flying box, it is used as a platform for weapons, communications, and missions that were not, indeed could not have been, envisioned by its designers." If the PLA gets access to the technical specifications for a "flying box" like the B-52, its ability to imitate, replicate, exploit, or mitigate the capability will be limited to the box itself. The container's specifications do not indicate the capabilities or technologies of the contents. The PLA may know what the DoD is building, but not how it will be used. This also allows the DoD to change the contents in unpredictable ways. Adopting open-system architectures and well-defined APIs are a key to implementing this recommendation.
- **Prioritize tactics and training.** While technology plays an important role in modern conflict, advances in technology do not generally make up for shortfalls in tactics and training, either

for the PLA or the DoD. Accordingly, the DoD's acquisition strategies should place a premium on interactions with operators throughout the entire development lifecycle. The DoD should make a concerted effort to remove barriers to training and tactic development (such as long development timelines, expensive operational costs, and small quantities of homogenous systems). Rapidly delivering large quantities of diverse systems with low operating costs creates opportunities for users to actively train and improve their skills, as well as to experiment and develop novel tactics. Like tacit knowledge, an operator's skill and creativity cannot be stolen or copied by an absorptive adversary.

Recommendation 6: Became a More Integrated Player

While the DoD should never envision adopting a top-down role that directs defense commercial enterprises, it can become a more involved player than it is today. This is especially true of the major U.S. defense primes that, on average, generate 80% of their revenue from government defense dollars and act as quasi-SOEs.

One prime area for greater DoD involvement is in the prioritization and monitoring of reimbursable IR&D investments. The DoD currently reimburses $4 to $5 billion annually, which is roughly equivalent to 8 to 10 Major Defense Acquisition Programs. A GAO assessment found that DoD does not generally review contractors' IR&D projects and that only about 38% align with the DoD's priorities. One conclusion was that most projects were focused on requirements in programs of record and not specifically on innovation. The DoD should more actively review contractors' proposed projects to ensure they fit within its current modernization priorities and are not overly duplicative of other investments

Another area that the DoD should have greater involvement in is improving competition. A GAO assessment found that the DoD did not compete 67% of its 183 major contracts on its largest programs. While most RDT&E contracts fared better, the DoD should explore improving competition rates for procurement efforts. As the DoD adopts more commercially oriented and less complex systems for mission applications, this will become important to maintaining a viable defense industrial base.

This may also help mitigate the recent consolidation trends among defense primes, which some attribute to "intense competition for fewer programs and contract awards." Using policy, guidance, and incentives, the DoD should push toward an environment where there are many more vendors of all sizes pursuing many more contracts. This will be achieved only by acquisition offices adopting new business models in which modular strategies are combined with digital tools and collaboration with the operational community on potential requirement tradeoffs.

Another area worth considering is the adoption of technology zones where a large SOE may serve as the hub of a larger ecosystem that includes many small and medium-sized defense businesses. While in China this ecosystem is often physical, as in an industrial park, there is no reason the United States cannot strive to develop virtual collaboration spaces around certain technology areas between large defense primes and specialized smaller companies. There will be intellectual property issues, and teaming arrangements will have to be well considered. However, future defense solutions will likely require the ingenuity of different contractors to combine technologies in new and interesting ways to provide a suite of warfighting options. The DoD should begin exploring ways that these mutually beneficial arrangements can be structured and fostered.

Recommendation 7: Maximize University Talent

The United States, and specifically the DoD, needs to ensure a robust level of S&T funding that is commensurate with growth from military competitors and the anticipated challenges. Many of the Pentagon's key modernization priorities, such as biotechnology, quantum science, and microelectronics, involve significant advances in and will most likely be solved in the top university laboratories. While the DoD may be underfunding S&T, there is potential for this to be corrected in the bills put forth by the U.S. House of Representatives and U.S. Senate, which would double the overall budget for the National Science Foundation (NSF).

The DoD should ensure deeper coordination with the NSF. In its FY22 budget request, NSF proposed adding a technology directorate with the primary goals of renewing NSF focus on rapidly bringing innovations to market. While these bills are more focused on economic goals, many of the research areas correlate to Department of Defense modernization priorities. The collective DoD S&T enterprise should follow the Air Force's example, in which it entered into strategic partnership with the NSF to identify key areas of common interest: space operations and geosciences, advanced material sciences, information and data sciences, and workforce and processes. Providing this level of engagement and clarity can help ensure that the NSF appropriately prioritizes those research areas.

UARCs provide an invaluable service to the military S&T community, the larger acquisition enterprise, and the warfighter. They are dedicated and specialized research centers at prestigious, technically oriented universities. They have security clearances and freedom from conflicts of interest. Yet funding for UARCs comes from the Services or individual customers without direct line-item funding in the budget. Funding levels across UARCs can also vary widely. With the appropriate researching and improved predictability, UARCs have the potential to play a much greater role in DoD innovation. They should have a dedicated funding line for a basic level of support to ensure retention of key researchers and infrastructure. As recommended by the Defense Science Board, the DoD should direct the Services to utilize UARCs to the maximum extent and employ them as agents of outreach across the research enterprise.

THE DOD NEEDS TO ENSURE A ROBUST LEVEL OF S&T FUNDING THAT IS COMMENSURATE WITH GROWTH FROM MILITARY COMPETITORS AND THE ANTICIPATED CHALLENGES.

China appears to have more fully integrated scientists into its larger defense acquisition system, as demonstrated by them serving on multiple military projects. This is almost unheard of in the U.S. system. The GAO has written broadly on this reality, noting that commercial best practices involve technology and product staffs working collaboratively. However, the DoD has no formal policy on fostering such collaborative relationships and significant cultural and process barriers remain. The DoD should correct this immediately. While the S&T community needs to have independence and room to explore the boundaries of science, it should also be encouraged to see those findings through to a viable product. This should not be the goal for every case, as some top-notch researchers should maintain their focus on discovery rather than fielding. However, there are many scenarios in which this would create substantial benefits both for the researcher and for the DoD.

Conclusions

The PLA's absorptive approach to technology presents several challenges, risks, and opportunities to the DoD. To maintain the technical advantages currently enjoyed by Western allies, the DoD and its partners must make a concerted effort to understand the PLA's strategies and approaches to defense technology development and innovation. This understanding should support a thoughtful risk assessment that neither overstates nor understates the situation, and that points to specific actions for the DoD to undertake.

The recommendations in this paper identify specific steps the DoD can adopt to minimize the benefits of the PLA's absorptive approach. These recommendations aim to make it harder, slower, and more expensive for any absorptive adversary—China or others—to catch up with the United States technologically. These recommendations do not require major overhauls of policies and regulations, and largely point to specific decisions and behaviors that the acquisition community can adopt within the current regulatory environment.

About the Authors

Dan Ward is a Senior Principal Systems Engineer at The MITRE Corporation. He previously served for more than 20 years as an officer in the U.S. Air Force, where he specialized in leading small, high-speed, low-cost technology development programs. Dan is the author of three books: *LIFT (2019), The Simplicity Cycle (2015/2022), and F.I.R.E.* (2014).

Matt MacGregor is an Acquisition SME at MITRE's Center for Acquisition and Management Sciences and a Space Operations Engineer in the Air Force Reserves. Matt spent 21 years as a military and civil service program manager, including as the F-35 Deputy Program Manager. His last five years in government before joining MITRE were at the Pentagon, where he served as a Division Chief in multiple headquarters acquisition roles.

For more information about this paper or the Center for Data-Driven Policy, contact policy@mitre.org

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