Strategic Competition for Emerging Military Technologies
Comparative Paths and Patterns

By Michael Raska

One of the most pressing issues in contemporary international relations is the expectation of a new era of intensifying strategic competition, characterized by the confluence of political, economic, and military-technological competitions in the context of major shifts in the global security environment.[1] At the forefront of this growing strategic rivalry is the contest for future supremacy over global security and economic institutional grids between the world's major military powers—the United States, China, and to a lesser degree, Russia.

The Trump Administration has adopted an unprecedentedly combative stance toward China—the 2017 *National Security Strategy* describes China as a "revisionist power . . . that seeks to displace the United States in the Indo–Pacific region," while the 2018 *National Defense Strategy* portrays China as "a strategic competitor" that is using "predatory economics," as well as its growing military capabilities, "to intimidate its neighbors."[2] The shift in U.S. perceptions amounts to a growing realization that its two-part strategy of "engagement and strategic balancing" toward China that began with the Nixon/Kissinger "China opening" in the late 1960s, has failed to achieve its main objective—to integrate China as a "responsible stakeholder" in the existing international system, while preserving a favorable balance of power that would dissuade China from trying to mount a serious challenge in the long-term future.[3] Increasingly, the policy narrative has shifted toward a contrary viewpoint—as a fast–rising power, China "embodies a more enduring strategic challenge"—it is reluctant to accept institutions, border divisions, and hierarchies of political prestige put in place when it was comparatively weak.[4] According to one observer,

> *it would be naïve to assume that China doesn't harbor longer-term strategic ambitions in the region that would allow it to emerge not only as a 'theater peer' of the United States but also as the most formidable Asian power that would be able to contest and effectively deter the United States.*[5]

Strategic competitions between great powers are not new; they have been deeply rooted in history—from the Athenian and Spartan grand strategies during the Peloponnesian War in the fifth century BCE, to the bipolar divide between the Soviet Union and the United States in the Cold War during the second half of the

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20th century. The character of the emerging strategic competition, however, differs from analogies of previous strategic competitions, most recently in the period of the Cold War, when the United States focused solely on maximizing the containment of the Soviet Union across all dimensions—political, economic, ideological, and military—while the Soviet Union countered with comprehensive efforts to shift the overall "correlation of forces" to favor Moscow.[6] Today, the United States faces an array of current and long-term security challenges across different geographical areas, while the Sino–U.S. relationship is much more complex in terms of integrating varying drivers of cooperation, competition, and conflict simultaneously. In other words, the global patterns of the strategic competition in the 21st century are more complex, unpredictable, and diverse, reflecting multiple competitions under different or overlapping sets of rules. Long-term economic interdependencies co-exist with core strategic challenges, while ideological and institutional contests focus on the making and interpretation of rules and norms. Consequently, the ways and means of engaging in strategic competitions vary from pursuing security and prosperity through cooperative and institutional terms strictly in the economic arena, to sharp political-military-technological competition for power and status. The latter essentially embraces the logic of long-term competitive strategies aimed to attain or sustain a comparative advantage—relative to peer adversaries—across geopolitical, technological, military, economic, and other areas in order to significantly constrain competitor's strategic options and choices.[7] At the core of the emerging strategic competition, therefore, is whether China and Russia will have the requisite capabilities to project power in the Indo–Pacific on par with the United States, and how the United States and its key allies in unison with other major powers will respond to such changes.

In this context, this article provides brief contours of the ways and means China, Russia, and the United States attempt to attain or prolong margins of their military-technological superiority in strategic competition for emerging advanced technologies such as artificial intelligence (AI), robotics, additive manufacturing (or 3D printing), and other disruptive technologies. Emerging technologies such as AI are widely regarded to be a crucial element of future military effectiveness and advantage. In theory (and often in practice), the possession of cutting-edge militarily relevant technologies equals more effective weapons systems, which in turn results in greater military power, which in turn translates into greater geopolitical power. For example, the application of novel machine-learning algorithms to diverse problems promises to provide unprecedented capabilities in terms of speed of information processing, automation for weapons platforms and surveillance systems, and ultimately, decision-making for more precision firepower. In doing so, the utility of AI in military affairs seems virtually endless—from real-time analysis of sophisticated cyberattacks and detection of fraudulent imagery to directing autonomous platforms such as drones, to new forms of command and control such as automated battle management systems that analyze big data and provide recommendations for human action. Consequently, the diffusion of AI will have profound implications for how militaries adopt new technologies; how on an operational level, militaries adapt to and apply new technologies, and our understanding of the future battlespace.

However, such technologies and resulting capabilities rarely spread themselves evenly across geopolitical lines. In the case of China, Russia, and the United States, the diffusion of new and potentially powerful militarily relevant technologies—as well as the ability of militaries to exploit potential—varies widely. As with any novel technologies in military affairs, there are complex organizational, conceptual, and operational barriers to innovation. These may include, for example, the reliability of advanced algorithms to enable systems to learn from surprises and adapt to changes in their environment, to adopting and adapting them into varying force structures and weapons platforms using novel operational concepts, and ultimately, designing ethical codes and safeguards on how to use them. At the same time, "militarily relevant advanced technologies" are becoming harder and harder to identify and classify. Technological advances, especially in the area of military systems, are a continuous, dynamic process; breakthroughs are always occurring, and their impact on military effectiveness and comparative advantage could be both significant and hard to predict at their nascent stages. In particular, many advanced technologies—many of which are embedded in commercial, rather than military industrial sectors—offer new and potentially significant opportunities for defense applications and, in turn, for increasing one's military edge over potential rivals. This can be seen in the convergence of emerging dual-use technologies, conceptualized under the term the "Fourth Industrial Revolution" (4IR) in the following areas (see Figure 1).[8]

The resulting unequal distribution, in turn, naturally affects how these technologies and capabilities may impact regional security and stability. Alliances may become more closely interconnected through technology-sharing and interoperability imperatives, while traditional strategic concepts such as deterrence may be tested through the emergence of different types of conflicts brought by new technologies. Consequently, it is critical to assess the relative abilities of regional militaries to access and leverage new and emerging critical technologies, their likely progress in doing so, and the impediments they may face, ultimately with an eye

Figure 1. Convergence of 4IR Dual-Use Technologies.

Perception, Processing, Cognition	Performance and Materials	Communication, Navigation and Targeting	Manufacturing, Logistics and Supply Chain
• Cloud Computing	• Quantum Computing	• Precision Position, Navigation and Timing	• Robotics
• Big Data Analytics	• Autonomy	• Directed Energy	• Additive Manufacturing
• Artificial Intelligence	• Novel / Smart / BioMaterials	• Electro-Magnetic Weapons	• 4D Printing / Smart Materials
• Cyber capabilities	• Meta-technologies	• Cyber Capabilities	• Synthetic biology manufacturing
• Virtual and Augmented Reality	• Composites for Aerospace	• Unmanned Systems	• Virtual and Augmented Reality Manufacturing / Simulation and Training / Computer Aided Design
• Robotics / Unmanned Systems	• Internet of things	• Hypersonics	
• Advanced Sensors	• Energy capture and storage	• Optical satellite links	
• Internet of things		• Visible light communication	

Source: TX Hammes, "Technologies Converge, Power Diffuses," Paper presented at RSIS-TDSI Seminar '*Disruptive Defence Technologies in Military Operations*', Singapore, June 29, 2016., available at <https://www.rsis.edu.sg/wp-content/uploads/2016/08/ER160823_RSIS-TDSI.pdf>.

toward how it will affect relative gains and losses in regional military capabilities.

Defense Innovation Trajectories: A Comparative Framework

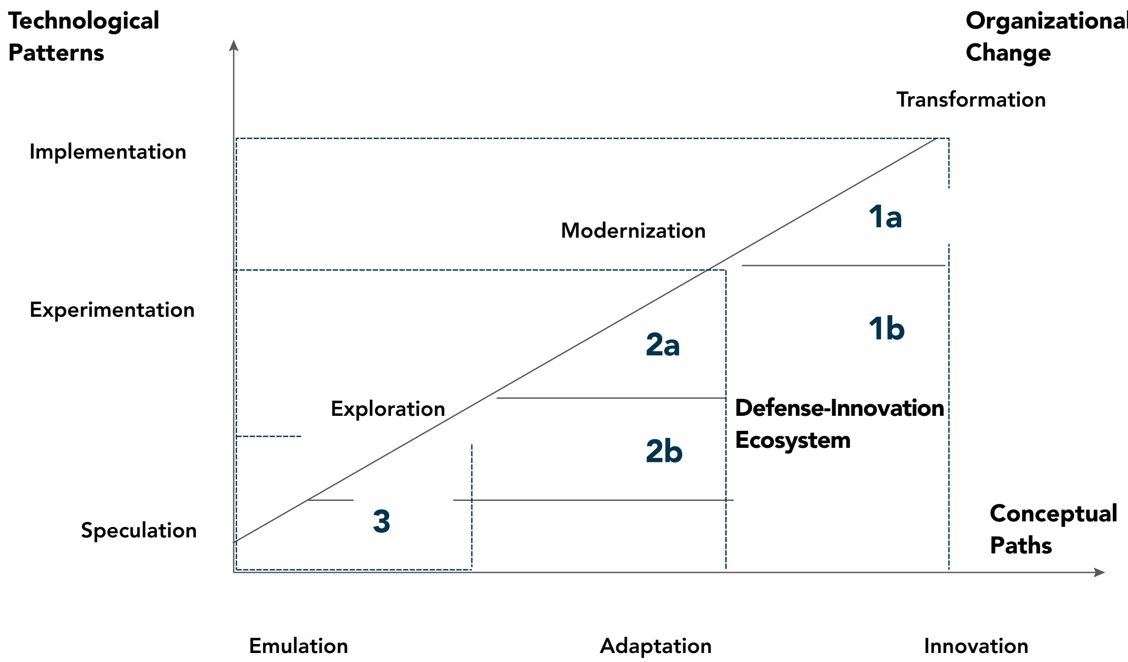
The growing strategic rivalries and the contest for future supremacy between the United States, Russia, and China shape different national responses to the same technological breakthroughs, conditioned by varying defense innovation trajectories, priorities, and resources. In order to project the varying trajectories, it is necessary to conceptualize a comparative framework for defense innovation that integrates the varying stages, paths, and patterns. To begin with, conceptualizing emerging technologies into military capabilities involves internal processes of military innovation as well as external benchmarking processes of adaptation or emulation.[9] A disruptive military innovation may not always require simultaneous technological, doctrinal, and organizational breakthroughs, but may span the spectrum between incremental modernization and discontinuous transformation. Based on these assumptions, one can triangulate defense innovation trajectories along three axes:

1. *conceptual paths*—emulation, adaptation, and innovation;
2. *technological patterns*—speculation, experimentation, and implementation; and
3. *organizational change*—exploration, modernization, and transformation.[10]

Defense emulation paths involve importing new tools and ways of warfare through imitation of other military organizations. Adaptation is defined through adjustments of existing military means and methods, in which multiple adaptations over time may lead to innovation. Defense innovation then involves developing broader military-relevant technologies, tactics, strategies, and structures. Farrell and Terriff observe that "it is only when these new military means and methods result in new organizational goals, strategies, and structures that innovation, adaptation, and emulation lead to major military change."[11] Similarly, according to Thomas Mahnken, military innovation may occur in three distinct but often overlapping phases: (1) speculation; (2) experimentation; and (3) implementation.[12] The speculation phase can be defined through novel ways for solving existing operational problems or acknowledging the potential of emerging technologies. As speculation turns into greater awareness, military services establish experimental organizations, battle laboratories, and units tasked with experimenting with new concepts, force structures, weapons technologies, and warfare methods. With the broadening and deepening experimentation processes a consensus emerges, when the military leadership and services decide to adopt, adapt, and later refine selected experimental operational concepts, warfare methods, organizational force structures, or new generations of weapons systems and technologies. The implementation phase is evident in a range of indicators: i.e. the establishment of new military formations; doctrinal revision to accommodate new ways of war; resource allocation supporting new concepts; development of formal transformation strategy; establishment of innovative military units; new branches and career paths; and ultimately, field training exercises with new doctrine, organizations, or technologies.[13]

In this context, one of the key sets of variables in the matrix is the level and sophistication of a country's defense-innovation ecosystem, which can be defined by a range of "hard" and "soft" innovation capabilities: from technological research and development (R&D) facilities and innovation clusters to non-technological factors such as political, institutional, relational, social, and ideational factors.[14] Together, these factors shape the relative

Figure 2. Conceptualizing Defense Innovation Trajectories.



Source: Michael Raska and Richard Bitzinger, "Locating China's Place in the Global Defense Economy," In Forging China's Military Might: A New Framework for Assessing Innovation, ed. Tai Ming Cheung (Baltimore, MD: Johns Hopkins University Press, 2013); Thomas Mahnken, "Uncovering Foreign Military Innovation," Journal of Strategic Studies 22, no. 4 (1999): 26–54; Theo Farrell and Terry Terriff, eds., The Sources of Military Change: Culture, Politics, Technology (London: Lynne Rienner 2002), 3–21; Andrew Ross, "On Military Innovation: Toward an Analytical Framework," SITC Policy Brief no. 1 (January 2010), 4–17, available at <https://escholarship.org/uc/item/3d0795p8>; Keith Krause, Arms and the State: Patterns of Military Production and Trade (Cambridge, Cambridge University Press, 1992), 12–80.

level of states' indigenous capabilities for independent defense-related R&D, science and technology (S&T) programs, manufacturing, and communities supporting innovation. The varying defense innovation ecosystems can be then broadly structured into three categories: Tier 1A/1B "critical innovators" at the technological frontier of defense production; Tier 2A/B of "adapters and modifiers" of advanced military-related technologies; and Tier 3 of "copiers" and "reproducers" of existing defense technologies.[15] By triangulating defense innovation paths and patterns, it is possible to ascertain the magnitude of organizational change in three stages: (1) exploration, (2) modernization, and (3) transformation.[16] Exploration includes both speculation and emulation, with initial attempts to develop new areas of technological expertise; modernization involves continuous upgrades or improvements of existing military capabilities through the acquisition of new imported or indigenously developed weapons systems and supporting assets.[17] Transformation can be then characterized in the context of a "discontinuous" or "disruptive" defense innovation that meets long-term policy and strategy.

China's Quest for Innovation

The Chinese defense, science, technology, innovation, and industrial base has made undeniable advancements over the past decade and a half in terms of developing and manufacturing new, relatively modern military systems that increasingly meet the widening operational requirements of the Peoples Liberation Army (PLA). Its progress has reflected Chinese military modernization strategy in a "double construction" approach of mechanization and "informatization" in order to concurrently upgrade and digitize the PLA.[18] This "two-track" approach has called for both the near-term "upgrading of existing equipment combined with the selective introduction of new generations of conventional weapons"—a so-called "modernization-plus" approach—together with a longer-term "transformation" of the PLA along the lines of the information technologies-led Revolution in Military Affairs.[19] In the process, China's long-term strategic military-technological programs have been deeply integrated with its advancing civilian science and technology base, which has been concurrently linked to global commercial and scientific networks.[20] In this context, China is continuously benchmarking emerging technologies and similar high-tech defense-related R&D programs in the United States, Russia, India, Japan, Israel and other countries.[21]

The key aim is to accelerate China's "absorptive capacity" to recognize, assimilate, and utilize external knowledge in the development of China's advanced technologies in both civil and military domains.[22] China calls this strategy "Indigenous Innovation"—first set in the "2006-2020 Medium- and Long-Term Defense Science and Technology Development Plan."[23] By pursuing Indigenous Innovation, China aims to circumvent the costs of research, overcome international political constraints and technological disadvantages, and "leapfrog" China's defense industry by leveraging the creativity of other nations. This includes exploitation of open sources, technology transfer and joint research, the return of Western-trained Chinese students, and, of course, industrial espionage, both traditional and increasingly, cyber-exploitation—i.e. systematic hacking.[24]

Notwithstanding these efforts, however, the Chinese arms industry still appears to possess only limited indigenous capabilities for cutting-edge defense R&D. Western armaments producers continue to outpace China when it comes to most military technologies, particularly in areas such as propulsion (aircraft/missile engines), navigation systems and defense electronics, and high-end composites. In retrospect, the confluence of historical legacies of centralized planning coupled with segmented technological, institutional, and management deficiencies such as overlapping planning structures, widespread corruption, bureaucratic fragmentation, problems with quality control, manufacturing, and process standardization have precluded the Chinese military-industrial conglomerates from leaping ahead on the innovation ladder. Most importantly, no real internal competition exists and the industry lacks sufficiently capable R&D and capacity to develop and produce highly sophisticated conventional arms. Confronting these challenges, China has progressively introduced a series of medium-and long-term defense industrial strategies, plans, and institutional reforms that have generally set two broad strategic objectives known as "two gaps:"

- to catch-up with the global military-technological state-of-the-art base by fostering "indigenous innovation," mitigate foreign dependencies on technological transfers and arms imports, while leveraging civil-military integration to overcome entrenched barriers to innovation; and
- to provide advanced weapons platforms, systems, and technologies that would enable the PLA's transformation into a fully "informatized" fighting force—one capable of conducting sustained joint operations, military operations other than war, and missions

related to China's strategic deterrence to protect China's core national security interests beyond national borders.[25]

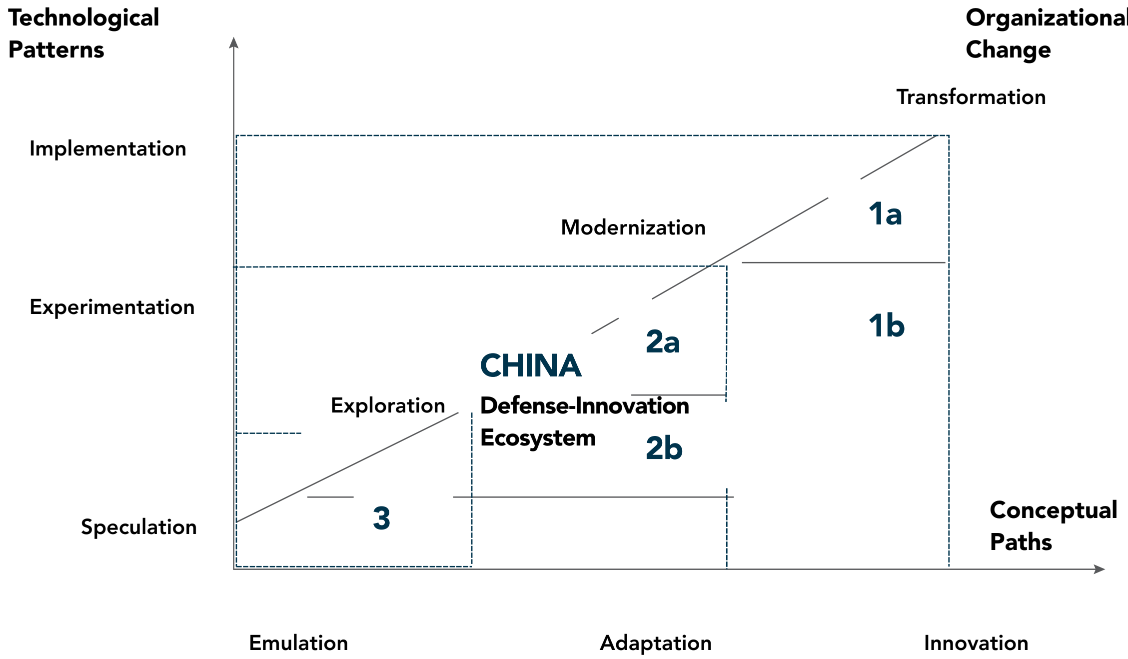
Under Xi Jinping, China's strategy to resolve both gaps has focused principally on upgrading civil and military convergence. In particular, since 2003, the conceptual umbrella for leveraging civil military integration (CMI) became known as *Yujun Yumin*—locating military potential in civilian capabilities—signifying transfer of commercial technologies to military use, and calling upon the Chinese arms industry not only to develop dual-use technologies, but also actively promote joint civil-military technology cooperation. Yujun Yumin has been prioritized in the 2004 Defense White Paper, subsequent Five-Year Defense Plans, as well as in the 2006–2020 Medium- and Long-Term Defense Science and Technology Development Plan (MLP).[26] Select dual-use technology development areas, for example, included microelectronics, space systems, new materials (such as composites and alloys), propulsion, missiles, computer-aided manufacturing, and particularly information technologies.[27]

Initially, China's political establishment envisioned CMI as institutional arrangements paving the way for a new round of associated management reforms for the defense industry, including allowing select civilian private sector firms to engage in defense work. These in turn would enable expanding linkages and collaboration between China's military-industrial complex and civilian high-technology R&D sectors. In 2016, however, President Xi Jinping elevated CMI into a national-level strategy noting that "the integration of civilian and defense development will involve multiple fields and enable economic progress to provide a 'greater material foundation' for defense construction, while the latter offers security guarantees for the former."[28] In other words, CMI has been projected not only as a key enabler to PLA's military-technological modernization, but more importantly, as a strategy for China's long-term sustainable growth, efficiency and productivity gains, as well as mitigating internal socio-economic and environmental challenges. Currently, CMI as a national strategy expands the integration of state-owned defense research, development, and manufacturing enterprises, government agencies under the State Council, universities, and private sector firms in order to advance the PLA's military modernization, while supporting China's economic growth.[29] In this context, China has created new agencies in 2017 such as the Central Commission for Integrated Military and Civilian Development and the Scientific Research Steering Committee, both tasked to advance the R&D of state-of-the-art weapons platforms and systems.[30]

At the same time, China's CMI places strategic importance on foreign acquisition of dual-use technologies, resources, and knowledge in selected priority areas identified in recent defense science and technology plans—such as the "13th Defense Science and Technology (S&T) and Industry Five-Year Plan;" "2025 Defense Science and Technology Industry Plan;" and the "Made in China 2025" advanced manufacturing plan.[31] According to the 2015 *China Military Strategy*, "China will work to establish uniform military and civilian standards for infrastructure, key technological areas and major industries, explore the ways and means for training military personnel in civilian educational institutions, developing weaponry and equipment by national defense industries, and outsourcing logistics support to civilian support systems."[32] In this context, China aims to achieve military advantage from key emerging technologies such as quantum computing and communications, hypersonics, artificial intelligence, big data applications, cloud computing, 3D printing, nanomaterials, and biotechnology by creating a modernised defence industrial base that leverages civil and military convergence.[33]

In short, the evolving strategy of Indigenous Innovation in a broader context of civil-military

Figure 3. China's Defense Innovation Trajectories.



Source: Michael Raska and Richard Bitzinger, "Locating China's Place in the Global Defense Economy," In Forging China's Military Might: A New Framework for Assessing Innovation, ed. Tai Ming Cheung (Baltimore, MD: Johns Hopkins University Press, 2013).

integration constitutes a pathway for China's long-term strategic competition.[34] In doing so, China continues to seek niche technological developments that could potentially revolutionize the PLA's military operations by providing a credible asymmetric edge in regional flashpoints in East Asia: i.e. anti-ship ballistic missiles (ASBMs), anti-satellite ballistic missiles, hypersonic cruise missiles, and systems converging cyber and space capabilities. Notwithstanding military-technological trajectories, China's military effectiveness will be increasingly influenced by its ability to align its political and strategic goals with technological advancements. This includes China's ability to alter strategic alliances and balance of power through international arms exports, technology transfers, and military cooperation. Overall, China is still more of a "fast follower," always playing technology "catch-up," or else a niche innovator when it comes to military R&D. Additionally, it may be acceptable to be a niche innovator if the military is only looking to gain asymmetric niche advantages, such as the PLA using an ASBM to attack aircraft carriers.[35] Ultimately, transforming emerging technologies into actual capabilities will be shaped by the PLA's ability to integrate novel technologies to joint military concepts.[36]

Russia's Return to First Offset

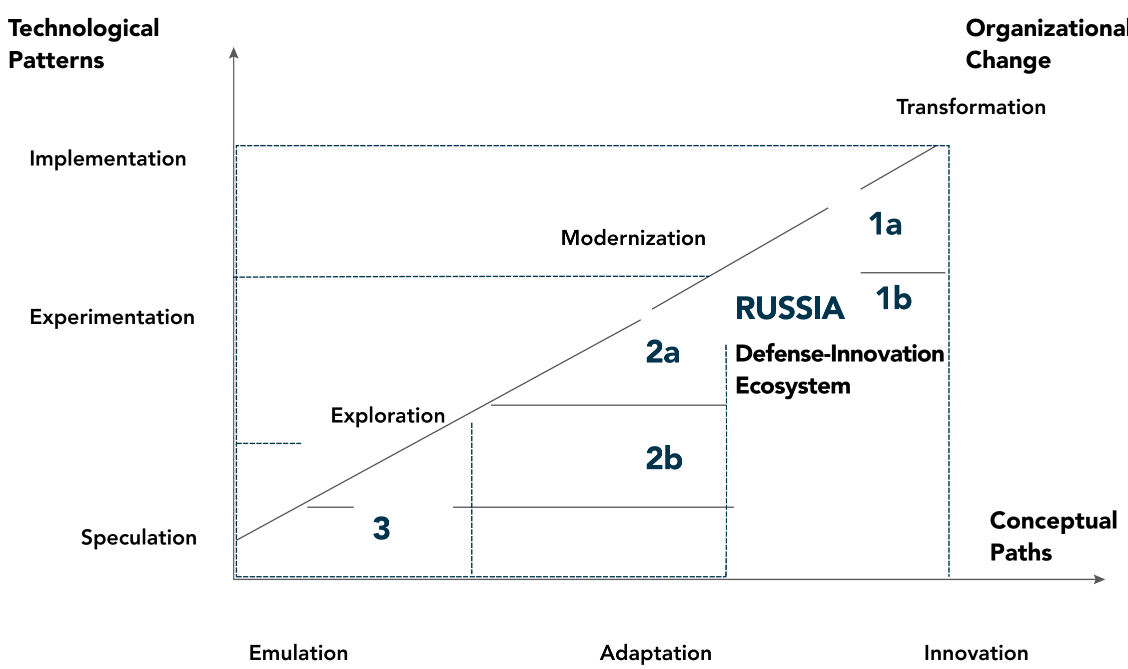
Russia has been closely monitoring the United States as well as China's technological priority areas, while assessing its long-term consequences, and searching for means to counter them.[37] In this context, Russian strategy has broadly consisted of two major elements: The first one is "countering the Third Offset Strategy with the First Offset Strategy," which means prioritizing the development of a wide array of both strategic and tactical nuclear weapons systems. In Russian strategic thought, maintaining a variety of sophisticated nuclear weapons can invalidate any conventional advantages of the United States, NATO, and China. Ensuring that Russia remains a nuclear superpower is the basis of all Russian security policies. Moscow has never ceased the development of strategic and tactical weapon systems even during the darkest days of 1990s, and indeed accelerated research and development during the period of swift economic growth in the 2000s. Russia sees nuclear weapons as the most cost-effective pillar of strategic deterrence. The Strategic Rocket Forces, the service that controls the Russian ground based ICBMs and serves as the main component of the Russian strategic nuclear triad, accounts for a mere 5 percent of defense expenditures.[38]

Notwithstanding Russia's recent economic downturn and defense expenditure cuts, select major nuclear-related projects continue to expand. For example, Russia has been deploying the new RS-24 *Yars* (SS-27 Mod 2) ICBMs, and the new *Borei* class SSBNs armed with RSM-56 *Bulava* (SS-N-32) missile systems. Simultaneously, however, Russia has been developing at least two additional ICBM families: a heavy liquid fuel *Sarmat* ICBM (RS-28) and a mobile solid fuel *Rubezh* (RS-26) system, specifically designed to defeat future U.S. missile defense shields in Europe. The development of a rail-based ICBM system utilizing one of the existing ICBM types (most likely RS-24) has also begun. Furthermore, Russia is working on hypersonic reentry vehicles for its ICBMs.[39] Another extensive program is the development of a significantly upgraded version of the *Tu-160 Blackjack* strategic bomber, which will be produced in Kazan. Moscow takes any possible threat to the effectiveness of Russian nuclear forces very seriously, and immediately embarks on planning countermeasures. In 2015, the Russian state-run TV, reporting on a policy meeting in the Kremlin, revealed, most likely intentionally, the existence of a bizarre strategic weapons project called *Status-6*—a 10,000+ km range nuclear-powered torpedo, capable of travelling at the depth of 1,000 meters at great speeds. The stated purpose of this weapon is to destroy coastal cities and installations with nuclear warheads, although different types of payload are also a possibility.[40]

Russia continues to develop and deploy a wide range of tactical nuclear weapons, including nuclear-capable cruise missiles, nuclear bombs, nuclear-capable SAM missiles for long-range SAM systems, nuclear torpedoes, and nuclear versions of short-range ballistic missiles. These projects, especially the rearmament of ten missile brigades of the Russian Army with the *Iskander* (SS–26 Stone) short-range missile systems, are also high priority.[41] Some of the Russian countermeasures are rather unique. Russia is the only country in the world which deploys medium-range cruise missiles (*Kalibr*, SS–N–30A) on small (less than 1,000 tons of displacement) corvettes. Such ships belonging to the existing *Buyan-M* and the future *Karakurt* classes are estimated to be produced in significant numbers. The *Buyan-M* corvettes were combat-tested as cruise missile carriers in the Syrian campaign as well as the new Russia project 636.3 (*Improved Kilo*) conventional submarines. Other delivery systems, including SS–26, Su–34 tactical bombers, and the new air-launched cruise missiles have also been combat-tested during the Syrian war. In short, Russia's programs focusing on rearmament of the nuclear forces are progressing into advanced stages. Russia already has a significant advantage over the U.S. in terms of the quality and variety of its delivery systems, and can reasonably ensure the strategic effectiveness of its nuclear forces in the near future.

The second element in Russia's strategy is more ambitious, carrying broader technological risks. Russia began to counter many U.S. and Chinese technological initiatives using similar indigenous programs, although more narrowly focused and smaller in scale. In October 2012, Russia established the Advanced Research Foundation (ARF)—a counterpart to the U.S. DARPA (Defense Advanced Research Projects Agency). The ARF focuses on R&D of high-risk, high-pay-off technologies in areas that include hypersonic vehicles, artificial intelligence, additive technologies, unmanned underwater vehicles, cognitive technologies, directed energy weapons, and others. While Russian technologies are at the early stages in some areas, in key areas such as directed energy weapons, rail gun, hypersonic vehicles, and unmanned underwater vehicles, programs are progressing into advanced stages, backed by considerable financing for many years prior to the ARF.[42] The key challenge for Russia, however, is sustained resource allocation to translate these "disruptive" innovations into actual military capabilities.[43] Since Russian resources are limited and its political relations with the West are unlikely to be normalized anytime soon, it is possible that Russia will try to establish new industrial partnerships with major non-Western countries such as India and China to secure financing and technological cooperation on these projects. Russia has already had a positive experience with India (*BrahMos* cruise missile joint production venture), and has embarked on two major joint programs with the Chinese—a wide-body passenger aircraft and advanced heavy helicopter programs. The interest in establishing the new joint programs with the Chinese is especially strong in the Russian space industry. The purchase of Chinese space-grade microchip production technology in exchange for RD–180 liquid-fuel rocket engine technology is under negotiation, and may start a new stage in Sino–Russian cooperation.

Figure 4. Russia's Defense Innovation Trajectories.



Source: Framework based on Michael Raska and Richard Bitzinger, "Locating China's Place in the Global Defense Economy," In Forging China's Military Might: A New Framework for Assessing Innovation, ed. Tai Ming Cheung (Baltimore, MD: Johns Hopkins University Press, 2013).

U.S. Defense Innovation Advances and Challenges

The U.S. defense community is debating a range of capability requirements and top priority investments that will shape U.S. strategy and the use of force in the 21st century. While mapping all major initiatives, concepts, and programs would transcend the scope of this article, one could argue that the U.S. Department of Defense (DOD) seeks to develop technologically enabled novel operational and organizational constructs that would sustain U.S. military superiority over its capable adversaries at the operational level of war, thereby strengthening conventional deterrence. One particular element, often emphasized by the DOD, is the importance of "institutional agility"—or improving the ability to out-innovate adversaries, rethink how the DOD sources technology and rethink its models for product delivery. In recent years, the DOD has aimed to streamline its science and technology engines, or S&T enterprises to support sustained research in fundamental technologies and quickly leverage emerging technical opportunities in the commercial sector, including cyber. In doing so, the DOD has aimed to use all potential sources of technical advantage, from traditional industrial base, non-traditional suppliers, and academia to help create competitive advantage by means of translating technical capabilities into solutions and concepts that would turn into capabilities to overmatch any threat. During the Obama Administration, these efforts were embedded in the concept of the *Third Offset Strategy*. The strategy became public in the 2014 Defense Innovation Initiative (DII), which was presented as a comprehensive effort for the U.S. defense community to search for innovative ways to sustain and advance U.S. military superiority in an era in which U.S. dominance in key warfighting domains has been eroding, while facing constrained and uncertain budgets.[44] The DII called for a revamped institutional agility that would accelerate U.S. military innovation in select areas, including leadership and defense management, long-range research and development programs to identify, develop, and field breakthrough technologies, a reinvigorated war-gaming effort to develop and test alternative ways of achieving strategic objectives, and novel operational concepts to employ resources to greater strategic effect. Similarly, the Third Offset Strategy sought to conduct numerous "small bets" on advanced capability research and demonstrations, while working to craft new operational concepts to determine capability requirements and top priority investments that will shape U.S. military strategy in the 21st century.[45]

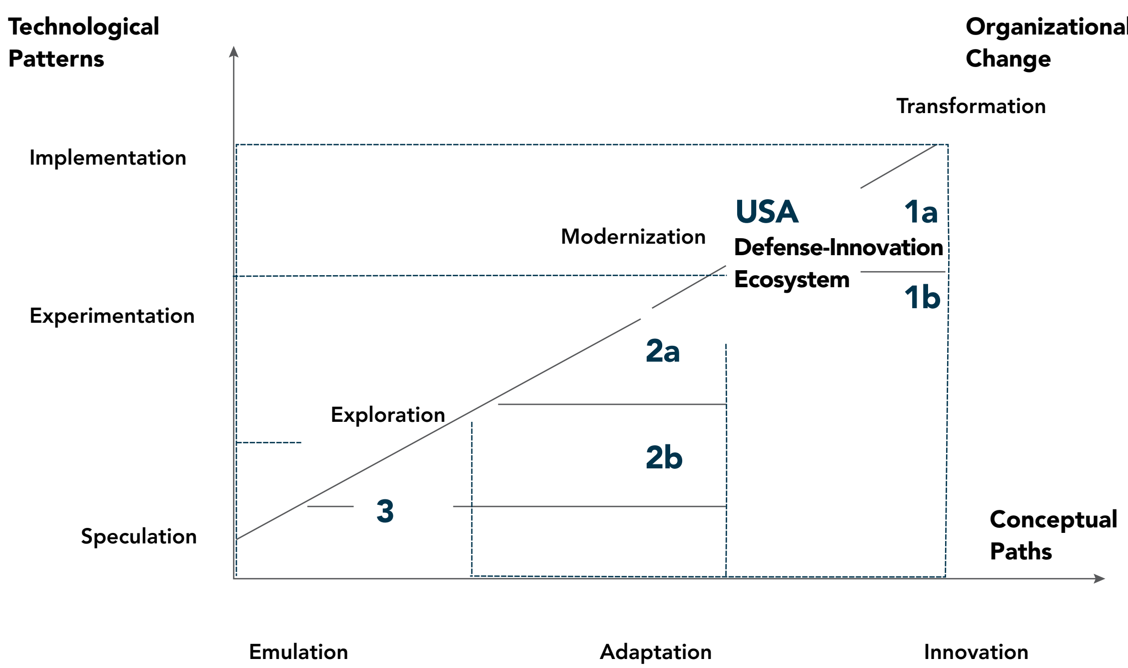
While the Trump Administration discarded the term Third Offset, its programs and priorities have arguably continued, aiming to exploit technologies of the Fourth Industrial Revolution to attain and prolong the margin of the U.S. technological superiority that may bring unprecedented military capabilities.[46] These include leveraging learning machines—integrating artificial intelligence and autonomy into an advantage; i.e. instantly responding against cyber-attacks, electronic attacks, or attacks against space architecture or missiles; human-machine collaboration—using advanced computers and visualization to help people make faster, better, and more relevant decisions; assisted human operations—plugging every pilot, soldier, sailor, and marine into the battle network; human-machine combat teaming—creating new ways for manned and unmanned platforms to operate; and network-enabled autonomous weapons—weapons platforms and systems plugged into a learning command, control, communications, and intelligence, or C3I, network. Other "hidden" priority areas associated with emerging technologies have also been cited in the context of cross-domain strategic deterrence capabilities, particularly converging nuclear and cyber deterrence.[47]

Overall, the United States continues its military innovation lead in terms of future-oriented technological patterns, conceptual paths, however, with relatively slow organizational adoption and adaptation. Strategic effectiveness of U.S. military innovation, however, will not only depend on the institutional agility and adoption capacity—the financial intensity and organizational capital required to adopt military innovations—but will also depend on the responses, resources, and counter-innovations by peer competitors. Notwithstanding the diffusion and convergence of novel technologies—electronic miniaturization, additive manufacturing, nano-technology, artificial intelligence, space-like capabilities, and unmanned systems that are likely to alter the character of conflict over time—the patterns of "challenge, strategic response, and adaptation" will continue to shape the direction and character of long-term strategic competitions.

Strategic Implications

In the 21st century, China, Russia, and the United States continue to pursue the development, acquisition, deployment, and exercising of new technologies as means to create advantages and influence events or the strategic choices of their competitors.[48] According to a recent study, there are four distinct but mutually-supporting competitive strategies: (1) strategies of denial; (2) cost imposing strategies; (3) attacking a competitor's strategy; and (4) attacking a competitor's political system.[49] Denial strategies seek to prevent an opponent from attaining political objectives by demonstrating military-technological capability to convince an opponent that a particular action such as an aggression cannot be successful. Cost-imposing strategies, meanwhile, aim to convince a competitor that the cost of a particular course of action is prohibitively

Figure 5. U.S. Defense Innovation Trajectories.



Source: Framework based on Michael Raska and Richard Bitzinger, "Locating China's Place in the Global Defense Economy," In Forging China's Military Might: A New Framework for Assessing Innovation, ed. Tai Ming Cheung (Baltimore, MD: Johns Hopkins University Press, 2013).

high, and in doing so, dissuade or deter competitors from taking a certain action. At the same time, such strategies seek to divert competitors' resources across seemingly important, but strategically non-essential economic, political, and military arenas. The third approach, attacking a competitor's strategy, seeks to narrow competitors' strategic choices into a virtually self-defeating behavior. Historical examples include the development of the U.S. AirLand Battle doctrine in the 1970s and 80s that convinced the Soviet Union of its inability to implement its preferred strategy. Currently, China's counter-intervention or anti-access/area-denial (A2/AD) strategy similarly aims to attack and negate the effectiveness of U.S. power projection strategies in East Asia. Finally, strategies attacking a competitor's political system seek to exploit subversive factions within that system. For example, during the Cold War, the U.S. Strategic Defense Initiative (SDI) amplified debates within Soviet leadership over the direction, character, and strategic utility to compete with the United States in space development.[50]

The character of the ongoing strategic competition suggests the presence of all four above-mentioned competitive strategies. Yet, there are contending debates and varying policy vistas with regard to the most fundamental aims, objectives, and motives that entangle the great powers in strategic competition. Central to these debates are questions including to what degree do China, Russia, and the United States aim to maximize the share of relative hard power as a means to attain their security, status, and influence to achieve geopolitical outcomes; whether economic interdependencies assure stability, peace, and prosperity, rather than amplifying economic competition that increases resource insecurity and the propensity for China and the United States to seize access and control of resources; whether territorial, maritime, and other border disputes coupled with more strident forms of nationalism have the potential to become more escalatory; whether the diffusion of ideological values, visions, and cultural preferences creates shared identity leading to cooperation or rather does it reflect a mirage of political, economic, and perhaps even ideological cohesion; and ultimately, whether multilateral institutions and norms converge global or regional security interests and lasting peace, or encourage great powers to seek control of the agenda, rules, and norms of international institutions to shape the prevailing order?[51]

The resurgence of great power rivalries, particularly notable in East Asia, coupled with intensifying arms competition for advanced military technologies suggests that while wars and conflicts are not inevitable, neither are they inconceivable. In potential military confrontations, however, between adversaries armed with substantial nuclear arsenals and stand-off precision strike systems, there are considerable escalatory risks. Accordingly, great powers are engaging in competitive strategies to avoid large-scale wars of attrition, and instead rely on "peacetime" non-military diplomatic, information, and economic actions coupled with paramilitary operations to gain influence and territory without having to escalate to a major conflict.[52] These "indirect" actions can include the use of information operations and political warfare, cyber-attacks, electronic warfare, as well as paramilitary operations in disputed areas. The progressive complexity of cyber and information operations is reflected in cross-domain strategic interactions, between cyber, physical, and cognitive information domains, civil and military spheres, and involving both state and non-state actors.[53] These include confrontations in and out of cyberspace, cyberattacks on physical systems and processes controlling critical information infrastructure, information operations, and various forms of cyber espionage. Accordingly, nearly all great powers are developing advanced cyber capabilities—whether defensive, offensive, or intelligence-driven—which are increasingly used as instruments of warfare—as a key enabler and force-multiplier of "kinetic" operations—enabling actions, capabilities, and effects in land, sea, air, space, and intelligence operations in all domains.

The resulting progressive complexity in strategic interactions and interdependencies between cyber, information, cognitive, and physical domains presents new challenges to traditional conceptions.[54] of the uses of force. In particular, the convergence of both military and non-military instruments of warfare through cyber and information means brought about through emerging technologies is often viewed in the context of two inter-related strategic challenges: (1) "cross-domain deterrence and compellence" (CDD&C); and (2) asymmetric anti-access/area-denial challenges—with both having significant impact on the character of warfare, particularly in East Asia. CDD&C refers to the act of deterring an action in one domain with a threat in another domain, where the domains are defined as land, under the land, at sea, under the sea, in the air, in space, and in cyberspace, and may often use economic sanctions and other diplomatic, political, and informational tools. In this context, CDD&C may leverage both deterrence—dissuading an actor from taking an action before they act; and coercive diplomacy—persuading an actor to stop a particular course of action after they initiated action. In other words, cross-domain coercion uses threats of force in multiple domains to influence an opponent's strategic choices.[55]

Consequently, when contemplating how emerging technologies may affect East Asian security and defense requirements, militaries in the region will need to explore the nature of the evolving strategic competition in the region. In particular, U.S. allies and strategic partners in East Asia, including Japan, South Korea, and Singapore, will have to plan for potential U.S. involvement in emerging conflicts in the East China Sea and South China Sea vis-à-vis China: what types of challenges does this present for them? How will they operate in a contested environment characterized by the diffusion of sophisticated longer-range adversary capabilities and methods such as ballistic missiles, submarines, weapons of mass destruction, and offensive space and cyberspace assets? At the same time, however, the character of future conflicts in the regional "gray zones" may also reflect low-intensity conflicts in "peripheral campaigns," rather than high-end missions—given the considerable escalatory risks. In a context where the battle space is crowded with both legally constituted combatants and non-combatants, this will present new challenges. Consequently, military-technological advantages will not be effective without corresponding *strategic, organisational and operational adaptability*—not only detecting new sources of military innovation, but also, changing military posture quickly and easily in response to shifts in geostrategic environment, military technology, resource allocation, organisational behaviour, and national priorities.[56]

Ultimately, the diffusion of emerging technologies shaping military innovation trajectories must be viewed in a relative context—through the lens of *competitive strategies* reflected in the efforts to develop effective counter-measures and responses. A key requirement will be the capacity of the select militaries to educate both the officer corps and the rank-and-file on the changing character of war, and what the laws of armed conflict permit military personnel to do. Under the conditions of strategic ambiguity, regional militaries will therefore have to redefine their "theories of victory." Taken together, new technologies will increasingly shape strategic choices in the 21st century, including defense planning, management, and technological priorities, propelling the need for strategic and operational adaptation and innovation to prepare for, fight, win, and deter new types of conflicts. PRISM

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