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Buying Time

Logistics for a New American Way of War

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15 YEARS

About the Author

Chris Dougherty is a former Senior Fellow for the Defense Program at CNAS. His research areas include defense strategy, strategic assessments, force planning, and wargaming. Prior to joining CNAS, he served as senior advisor to the deputy assistant secretary of defense for strategy and force development at the Department of Defense. During this time, he led a handful of major initiatives, including the development and writing of major sections of the 2018 National Defense Strategy.

About the Defense Program

Over the past 15 years, CNAS has shaped U.S. defense strategy and policy. Today, the United States must significantly and swiftly adapt its defense strategy, develop innovative operational concepts, and promote difficult institutional reform to meet the long-term challenges posed by great powers and strengthen deterrence for decades to come. The CNAS Defense Program addresses the central military challenges of today and tomorrow and offers recommendations for how to balance risk across time. By linking strategic, budgetary, and operational analysis, we provide concrete recommendations to help decision makers make hard choices to effect necessary change; reverse the erosion of U.S. military advantages vis-à-vis China and Russia; and better manage other persistent threats. Our work leverages innovative and engaging approaches, such as wargaming, to inform current and future defense policy and strategy and develop the next generation of defense leaders. Decision makers in D.C. and around the globe trust our high-quality analysis and policy recommendations on U.S. defense strategy, force structure, operational concepts, budgets, and institutional reform.

Acknowledgments

I would like to thank the following people: ED McGrady and Alec Barker for being my partners in wargaming and analysis throughout this project. The CNAS staff and interns who have helped put on our wargames and served as notetakers, in particular Jennie Matuschak, Hannah Dennis, and Ripley Hunter. For reviewing the paper and providing their thoughts, feedback, and edits: Alec Barker, Billy Fabian, Mike Black, Tony Smith, Tim Walton, Bill Crowder, Andrew Metrick, Jacob Cohn, and Walker Mills. All our wargaming "regulars," without whom this project would not have been possible. Becca Wasser for literally everything she does—I would enumerate all the ways she helps, but then I would be here all week. Maura McCarthy for her superb work editing the first unwieldy drafts and getting this paper into shape. Finally, our publications team, Emma Swislow, Melody Cook, and Rin Rothback, for helping me get this over the line, and Stacie Pettyjohn for her patience, direction, and leadership. This report was made possible with the generous support of the Smith Richardson Foundation.

Dedication

This paper is dedicated to two people whose ideas influenced it. Dr. John Stillion is an outstanding mentor and great human being who taught me about the importance of logistics in military operations and wargaming. Art Corbett was one of the sharpest military minds and most well-liked people I have ever met. His contributions to our wargames and his thinking on distributed maritime logistics heavily influenced this paper. RIP, Art.

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Executive Summary

Discussions about defense strategy that focus on combat units and fail to account for logistics are irrelevant when it comes to understanding how well the United States can deter or defeat aggression by China or Russia. Planes, ships, and tanks are just weapons systems; making them combat capabilities requires getting them and their crews into the fight; supplying them with fuel, food, water, medical care, and munitions; and keeping them maintained. Logistics, more than the quantity of forces or the quality of technology, will determine the potential combat power available to the United States in future conflict scenarios with China or Russia. It will influence Chinese and Russian decisions about going to war, and when, where, and how to fight. It will bound the military courses of action available to U.S. commanders and delineate the strategic options available to presidents.

Despite this critical role, the Department of Defense has systemically underinvested in logistics in terms of money, mental energy, physical assets, and personnel. Neglect of logistics arguably became most severe in the post–Cold War era. Pressure to save money through efficiency and misguided attempts to run the department like a "lean" business disproportionately impacted logistics. Maximizing the ratio of combat "tooth" to logistical "tail" saved money, but at the cost of leaving U.S. armed forces with a logistical system that is stretched thin supporting peacetime operations and wholly unsuited to the demands of warfare with China or Russia.

Recognizing U.S. dependence on strained logistics networks, China and Russia have developed means to attack these networks, including long-range missiles and cyberattacks. Barring changes to U.S. logistics and sustainment concepts, such attacks present a grave threat to the department's ability to uphold U.S. security commitments in East Asia or eastern Europe.

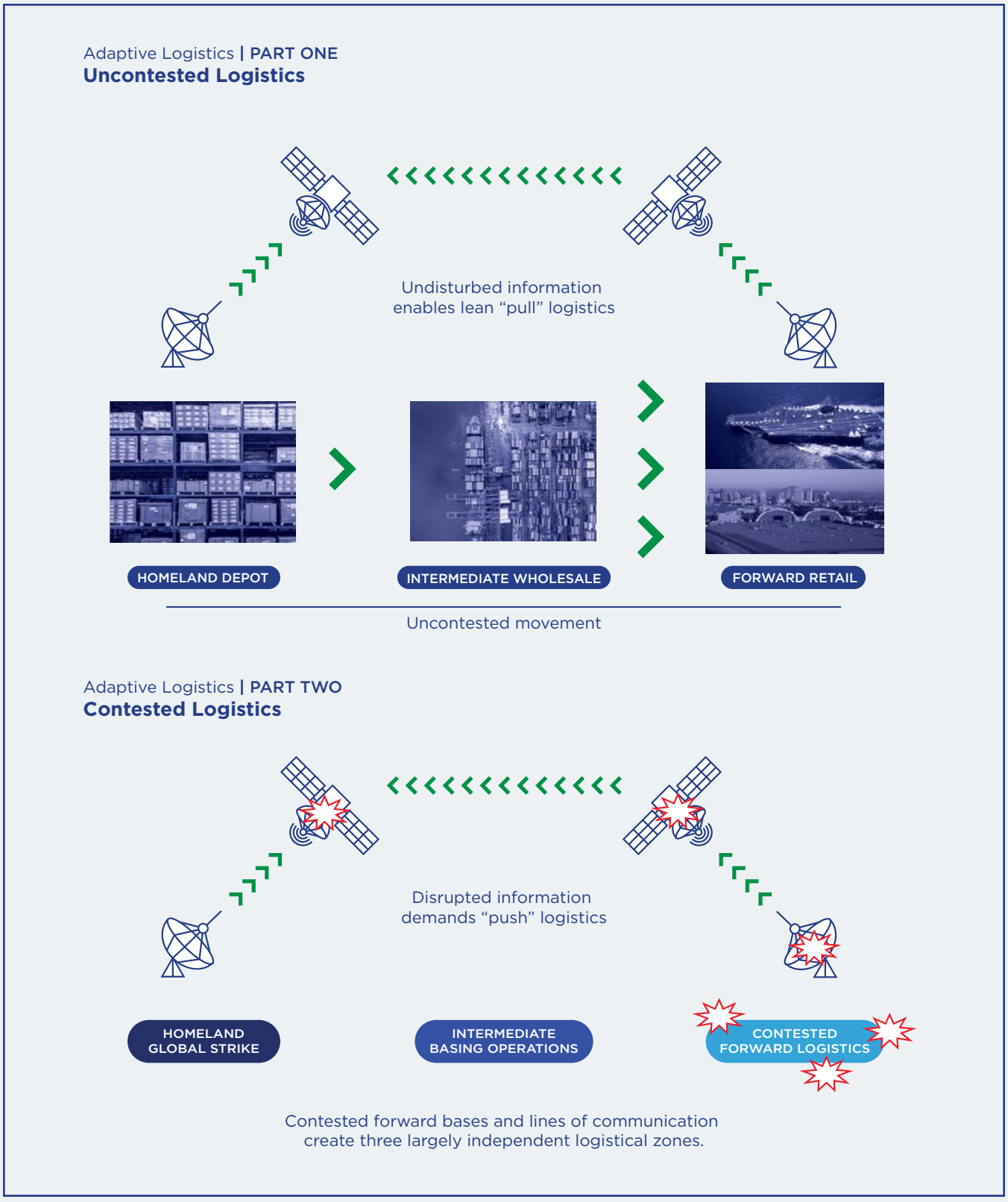
The logistical challenges facing U.S. forces in a conflict with China or Russia are severe but surmountable. Fixing the problem requires evolving from traditional methods focused on efficient delivery of supplies and services toward an adaptive logistics concept in which methods of support shift in response to threats, operational demands, and the availability of information. There is no single "correct" method of support. Instead, the joint logistics enterprise needs to invest in resiliency and train for contested wartime environments while sustaining everyday operations in an efficient manner. Unlike past wars in which U.S. logistical forces have adapted their methods on the fly, conflict with China or Russia may be too rapid and disruptive to permit a wartime overhaul of forces and methods. Adaptation must therefore be built into U.S. logistical concepts, forces, and posture from the outset.

In conflicts with China or Russia, adaptive logistics would differ from current methods in two critical ways. First, the physical structure of logistical networks would eschew the "depot-wholesale-retail" model, in which supplies and services flow sequentially through three zones: rear areas, intermediate lines of communication and bases, and tactical distribution networks. Instead, adaptive logistics envisions these zones operating largely independently during the critical opening weeks of a conflict to bring combat power to bear directly against a potential adversary as quickly as possible. In this model, U.S. forward forces would need to operate with minimal logistical support for weeks at a time. Intermediate bases and the open ocean would become bases for maneuver and offensive strikes, rather than transshipment zones. The homeland would become a base for persistent global strike operations, rather than a supply depot.

Second, providing logistical support in degraded information environments requires major alterations to information management and command and control processes. Information is the currency of logistics. It enables logistical supply to meet operational demand. Without it, logistical systems underperform or break down. Adaptive logistics requires an ability to shift between optimized and efficient "pull" models—wherein forces request support—and more resilient push models, wherein logisticians send support forward based on predicted demand. Adaptive logistics also necessitates better data collection, modeling, and analysis to use data and artificial intelligence to manage logistics.

Author's Preface: The research for this paper began in 2019, and most of the writing was complete in 2021, long before Vladimir Putin decided to invade Ukraine. The early lessons of Russia's invasion strongly reinforce the paper's key points about the importance of logistics and the need to invest in logistical concepts and capabilities that are resilient under combat conditions.

FIGURE 1: ADAPTIVE LOGISTICS: UNCONTESTED VS. CONTESTED
This figure compares the current, efficiency-focused "depot-wholesale-retail" model of uncontested logistics with the more resiliency- and sufficiency-focused adaptive model of logistics for contested environments.



Building an adaptive logistics concept will require major changes across the entire joint logistics enterprise. Four areas in particular merit substantial reforms and investments:

- Building a more resilient overseas posture is central to an adaptive logistics concept. The size, shape, and locations of U.S. forces, bases, and other key nodes overseas help define both logistical supply and demand. Making these forces and locations more resilient to Chinese and Russian attack must therefore be a top priority.
- Creating a larger and more diverse fleet of connectors—airlift, sealift, trucks, aerial refueling tankers, fleet oilers, etc.—will increase resilience to attrition while enabling logistics forces to better support more distributed operating concepts.
- Acquiring information systems that balance visibility and security will enable logisticians to track assets, understand logistical statuses across the joint force, and allocate resources effectively while under cyberattacks and other forms of information warfare.
- Investing in a larger and better-trained workforce is critical because many logistical processes are personnel intensive. Supporting distributed operations in contested environments requires the right personnel in the right locations at the right time with the right training.

The changes and investments required to create an adaptive logistics concept for operations against China or Russia are significant, but they are affordable relative to major changes in the composition or size of combat forces. Logistics systems tend to be less expensive than combat weapons and, given Chinese and Russian tendencies to target logistics, they can generate more effective combat power per dollar in potential combat scenarios. Put simply, building an adaptive logistics concept and supporting capabilities will have a tremendous return on investment for deterring or defeating Chinese or Russian aggression.

Executing the preceding conceptual, material, and fiscal shifts will require a cultural transformation in the way the Pentagon and the broader national security community treat logistics. Before change can occur, the Defense Department must realize that logistics is a critical combat function, rather than a menial support mission that can be marginalized or outsourced. The perspective of logistics as subordinate and external to "real" combat forces is not unique to the present-day United States, but it is uniquely detrimental to a nation that, due to its geography and strategic commitments, depends heavily on logistics to conduct military operations. Enacting this cultural change will be difficult and will require concrete action to better integrate logistics into key planning and budgeting processes and to develop analytic methods and metrics that better represent logistical challenges.

Given the scale of the changes outlined, developing an adaptive logistics concept will not be easy or without costs. Nevertheless, it is a strategic imperative if the United States intends to deter or defeat Chinese or Russian aggression. Continuing to squeeze savings and efficiency out of logistics will exacerbate a glaring vulnerability that U.S. adversaries are all too willing to exploit.

Introduction

> The quartermaster's claim upon history may, at its root, lie in the effect of logistics upon timing. At any given instant, supply determines whether or not forces can put a given plan into action … The longer a nation requires to bring its force to bear, the more time its enemies have to seize whatever objectives they consider desirable. Therefore, the supply and movement of military units not only affects what friendly forces can do, it also helps determine what the enemy can do.[1]

Logistics is the "dismal science" of warfare. Physical realities define an area wherein spreadsheets matter more than stratagems. Logistical constraints are inexorable and inflexible. Without transportation, forces cannot get into the fight. Without fuel, vehicles cannot operate. Without maintenance, they break down. Without munitions, forces cannot attack or defend. Without food, water, shelter, and clothing, personnel cannot survive. Without medical services, wounded personnel die.

Recognizing these constraints and the unique demands of projecting military power across the Atlantic and Pacific Oceans, the United States has maintained an unparalleled military logistics and sustainment capability since at least World War II.[2] The ability to move, supply, and maintain armed forces globally has undergirded modern U.S. defense strategy and foreign policy ever since. Logistics and sustainment allow U.S. armed forces to persistently patrol sea and air lines of communication, defend allies and partners forward, reinforce threatened areas of the security perimeter, and deliver devastating conventional or nuclear retaliation if necessary. Indeed, U.S. logistics has proved so effective over the last 30 years that the ability to move forces quickly to a combat theater and keep them supplied and maintained indefinitely are core assumptions in U.S. national security and defense policy. Unfortunately, a combination of shortsighted U.S. decisions and farsighted adversary investments has upended these assumptions and eroded the foundation supporting U.S. military operations. This upheaval threatens the credibility of U.S. security commitments to allies and partners in eastern Europe and the Indo-Pacific.

Maintaining U.S. logistical capabilities has never been cheap or easy. It demands, among other things, thousands of vehicles; a vast network of bases, ports, airfields, storage facilities, depots, pipelines, refineries, hospitals, and rail yards; enormous quantities of data, computers to store and process it, and networks to transmit it; and a large and well-trained military, civilian, and contractor workforce managing relations with a vast and complicated web of commercial entities.

Even though it plays a critical role in U.S. national defense, this cost, combined with the armed services' enduring bias in favor of combat forces, has tended to limit peacetime investments in logistics and targeted these assets as sources of savings during budget cuts. This tendency accelerated in the post–Cold War era. Steep budget and force-structure cuts, combined with a desire to lower costs by running the Department of Defense like a "lean" business, created consistent pressure to reduce logistical "tail" in favor of combat

The Berlin (left) and Kabul (right) airlifts in 1948–1949 and 2021, respectively, epitomize how the Department of Defense's unrivaled logistical capabilities create options for U.S. policymakers. (U.S. Air Force and Victor Mancilla/U.S. Marine Corps)

"tooth" and to outsource logistics and sustainment functions to the private sector wherever possible.[3] While well-intentioned—saving taxpayer dollars is laudable—these changes resulted in a lean but brittle logistics and sustainment system. Its centralized, streamlined structure aspired to optimality for peacetime efficiency, rather than resilience to the fog, friction, and attrition of war.

As it was reducing its logistical capacity, the Pentagon also began pulling forward-stationed forces back to the United States. Under the circumstances, the logic of this shift was sound. The Soviet threat receded, then crumbled. The American people wanted a "peace dividend" and a prosperous economy, and bringing forces home created jobs in congressional districts. From a strategic perspective, the shift back to the homeland offered greater geographic and political flexibility in an era of diffuse and unpredictable challenges.[4] The post-9/11 era—in which the United States fought a war in Afghanistan, a global counterterrorism campaign, and a second war against Saddam Hussein's Iraq—seemed to validate this approach.

The convergence of these two trends created a rather obvious problem. The Persian Gulf War demonstrated that responding to unforeseen threats required transporting forces quickly from a global posture to a combat theater and sustaining them once there. However, the capacity to do this was limited and declining due to budget reductions. The Pentagon and Congress responded to the lessons learned from the Gulf War by increasing Army and Marine Corps pre-positioned stocks and expanding the capacity of the Military Sealift Command. These limited changes improved U.S. strategic mobility in the 2003 invasion of Iraq. However, as during the preceding Gulf War, Iraq could not contest the flow of forces and materiel into the theater, nor could it disrupt logistics and sustainment from bases in the theater of operations. Despite the lack of interference, it still took over six months to deploy the invasion force and build the "iron mountain" of materiel needed to sustain initial combat operations in Operation Iraqi Freedom.[5]

The prevailing conditions during the wars with Iraq became the assumptions that defined post–Cold War defense planning and the consequent logistical and sustainment requirements.[6] Faster responses were better, but time was on the side of the United States. Adversaries would not be able to contest or disrupt the movement of forces and materiel into the theater. U.S. forces would have access to secure ports, airfields, and other critical

It took U.S. logisticians months to build the massive "iron mountain" of materiel that supplied U.S. forces during Operation Desert Storm. This image from 1991, which shows Army trucks packed tightly aboard a Military Sealift Command ship, captures the effort to redeploy that equipment back to the United States. (Gary Butterworth/Department of Defense)

infrastructure. The post–Gulf War tweaks focused on improving the Department of Defense's ability to execute the types of conflicts with which it was already comfortable: expeditionary warfare against small or middling military powers. In these conflicts, logistics might occasionally raise minor hurdles, but it would not be a serious strategic impediment.

China and Russia will attack U.S. "combat multipliers" with the goal of making them "combat denominators."

The emergence of China and reemergence of Russia as military competitors, commingled with technological shifts, have created an entirely different set of challenges. The military strategies of the Chinese People's Liberation Army and the Russian Armed Forces bring together advanced weaponry, disinformation, and deception to create systemic disruption, degradation, and destruction at the operational and strategic levels of war.[7] In Pentagon vernacular: China and Russia will attack the "combat multipliers" that make the total power of U.S. forces greater than the sum of their parts, with the goal of making them "combat denominators" that collectively reduce U.S. combat effectiveness.

China and Russia observed the Gulf War and other post–Cold War U.S. military operations and clearly identified logistics and sustainment systems as potential combat denominators. Logistics is a critical U.S. strength, but it is brittle and ripe for disruption after decades of cutbacks and inattention. Why attack a heavily defended U.S. carrier strike group, for instance, when one could just as easily attack the undefended Combat Logistics Force ships that supply it with fuel and munitions? Accordingly, China and Russia have invested in military capabilities such as precision-guided missiles, cyberweapons, electronic warfare systems, and anti-satellite weapons that can disrupt, degrade, and destroy major parts of the physical, digital, and human architecture of U.S. logistics. Their military strategies wield these weapons to disrupt U.S. sustainment, logistics, and mobility, thereby creating temporary local military advantages that they can exploit to achieve their political objectives.

These developments have upended post–Cold War U.S. planning assumptions. In future conflicts with China or Russia, time will not be on the side of the United States. The movement of forces and materiel into the theater will be disrupted and contested. Information systems that enable efficient distribution of assets and supplies will become vulnerabilities. Critical infrastructure may be inaccessible, damaged, or destroyed. Under these attacks, U.S. forces would likely be unable to generate meaningful combat power where and when it is needed. U.S. forces will also lack sufficient time to halt adversary aggression, set the theater, build combat power, seize the initiative, and launch decisive counteroffensives. This methodical phased approach that U.S. forces have used since the Gulf War takes months under benign conditions; in contested environments the timelines would be even longer. In the meantime, China or Russia would likely seize their objectives and offer to negotiate from a position of strength.

Addressing this challenge requires more than the limited tweaks implemented after the Gulf War. Instead, preparing for future conflicts with China or Russia demands a wholesale reconsideration of the ways U.S. forces conduct logistics and major investments in new means of execution. Indeed, if readers take one lesson away from this paper, it should be that debating military strategy, operational concepts, or force structure without first considering logistics renders these discussions irrelevant to understanding how well that force will perform. Planes, ships, and tanks are just weapons systems;

China's DF-26 intermediate-range ballistic missile is often called the "Guam killer." It can carry both conventional and nuclear warheads and is capable of striking land and maritime targets at ranges exceeding 1,600 nautical miles (3,000 kilometers). (Andy Wong/Pool/Getty Images)

making them actual combat capabilities requires getting them into the fight, supplying them with fuel and munitions, keeping them maintained, and keeping their human operators alive and healthy. This kind of holistic, systemic thinking is important for any military organization, but it is critical for the United States given its strategic position and global commitments.

> **Debating military strategy, operational concepts, or force structure without first considering logistics renders these discussions irrelevant to understanding how well that force will perform.**

This paper—part of the CNAS project "A New American Way of War"—proposes a conceptual framework and supporting initiatives for reforming and rebuilding U.S. military logistics to meet the challenges posed by China and Russia. It is the product of two years of research, workshops, wargaming, quantitative analysis, and computer modeling. The paper comprises six sections. The section after this introduction briefly describes the scope of this paper and its research methodology. Next, the paper discusses Chinese and Russian threats to U.S. logistics. Based on these threats and the demands of future combat operations, the paper then argues for an adaptive logistics concept that can modify its structure and practices to meet advanced threats and new operational concepts. After describing the concept, the paper discusses implementing adaptive logistics across four key areas: posture, information networks, connectors, and people. The paper concludes by discussing how building logistics systems for conflict with China or Russia will require lasting changes to Defense Department budgeting, culture, and processes.

Scoping and Methodology

Logistics is a broad topic covering functions as diverse as force deployment (mobility), depot maintenance, hygiene services, and contractor management.[8] Moreover, unlike many military functions, which only occur during combat or exercises, logistics and sustainment take place globally every day across the force. Rather than cover every aspect of logistics, this paper emphasizes combat operations against China in the Indo-Pacific and Russia in eastern Europe. Given this emphasis, the paper focuses on three logistics functions that, based on wargaming and analysis, tend to drive strategic and operational outcomes in conflict scenarios:

1. Mobility, or the movement of military forces. This includes strategic mobility into a combat theater, as well as intratheater movement;
2. Supply of munitions and fuel, to include transportation from storage facilities and distribution to units; and
3. Theater maintenance and munitions handling, or keeping ships, aircraft, and vehicles operating and loaded with weapons.

Notably missing from this scoping are attacks on Chinese or Russian logistics and sustainment systems, and discussions of U.S. mobilization, the defense production base, or commercial supply chains. In the case of the former, the focus of this paper and the broader project is on U.S. concepts. Attacks on adversary logistics systems have merit, but require further study beyond this project. Mobilization, defense production, and supply chains are crucial topics but outside the operational focus of this project and, as such, are excluded. With that said, the following topics likely merit further exploration: the ability of the defense industrial base to support protracted high-intensity operations—specifically in critical areas such as preferred munitions; the ability of the Defense Logistics Agency to acquire adequate fuel supplies in the Pacific theater; the security and reliability of supply chains for critical components such as semiconductors; and the mobilization ability of the United States.

This paper's methodology reflects the complex and rigorous nature of the topic. It began with literature research to formulate questions and hypotheses explored in two workshops—one each on China and Russia—featuring experts on logistics, Chinese and Russian military thinking, and future warfare concepts. Using insights from these workshops and research, the Center for a New American Security (CNAS) ran two wargames to examine logistics in a China-Taiwan conflict and a Russia-Baltic conflict. The outcomes of these wargames and workshops then informed quantitative analysis and computer modeling of different logistical concepts and force designs to better assess their validity across a wider range of conditions and assumptions. Drafts of this paper and analytic results were shared with a diverse group of logistical experts from across the defense community. While the paper involves the expertise and ideas of countless contributors, any errors are the author's alone.

Chinese and Russian Threats to Logistics

The concepts and initiatives described in this paper are designed to overcome the threats that China and Russia pose to U.S. logistics and the constraints these threats can place on the time and combat power available to the United States during a potential conflict.[9] This section briefly explains these threats by drawing on unclassified analysis of Chinese and Russian military strategies, concepts, and weapons systems. Additionally, this section draws on dozens of CNAS wargames, citing examples of Chinese and Russian "red team" actions where appropriate.

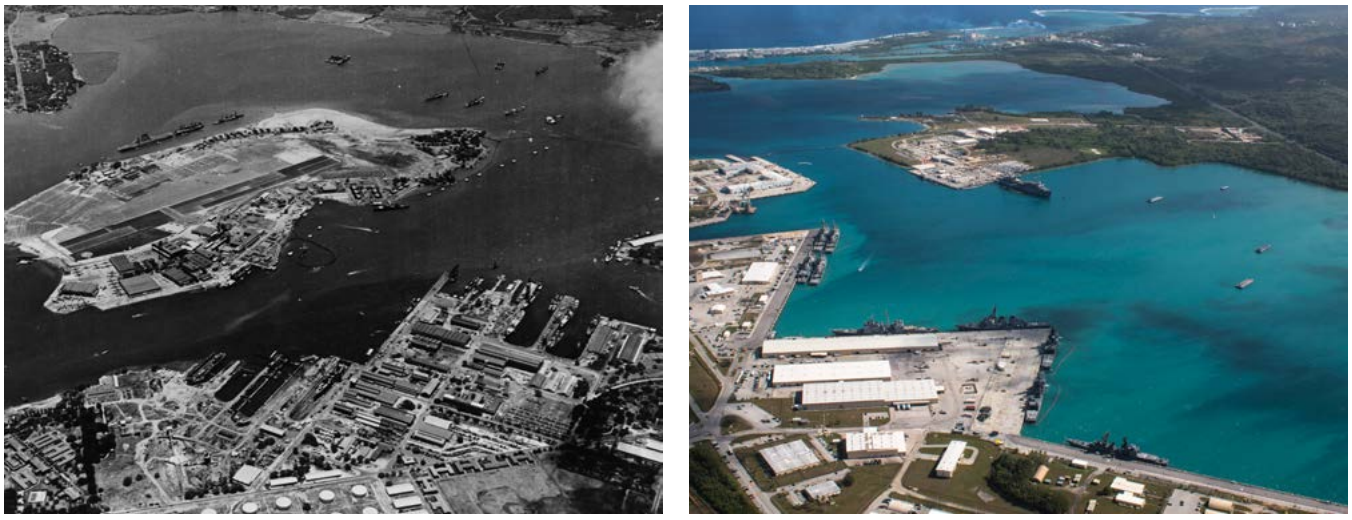
China and Russia face different military challenges from the United States and have distinct methods and means for fighting U.S., allied, and partner forces.[10] However, there is significant overlap between their strategies, concepts, and capabilities. In the United States, both face an adversary with greater aggregate global military power in the 2030 timeframe, and this gap only grows with the addition of allies and partners. Add in the U.S. nuclear arsenal, and maximalist military strategies for fighting the United States become self-defeating, if not suicidal.[11] From a strategic perspective, if China and Russia feel they must risk war with the United States in the next 10 years, they will aim to control the war by keeping it limited, local, and short.

As part of a limited-war strategy, China and Russia would attack logistics and sustainment to restrict the ability of the United States and its allies and partners to generate combat power in the theater; prevent rapid reinforcement of the theater; and disrupt, degrade, and increase the cost of sustaining combat operations from a global posture. These attacks would extend the time in which China or Russia would enjoy a localized military advantage, thereby enabling them to seize their objectives and begin pushing for negotiations and conflict termination from a position of strength. Unsurprisingly, Chinese and Russian threats align with the four key areas identified in the introduction: posture, information networks, connectors, and people.

U.S. overseas posture, and particularly any location where logistics functions or assets are concentrated, is a high-priority target for Chinese and Russian attacks. This conforms with their military strategies, which emphasize the use of long-range precision missiles or cyberattacks to disrupt U.S. forces systemically.[12] Key targets include ports, airfields, rail yards, bridges, major pre-positioning or maintenance facilities, and locations where U.S. armed forces conduct reception, staging, and onward integration of forces from outside the theater.

Attacks on U.S. overseas posture can be acutely disruptive because the post-Cold War quest for greater efficiency has concentrated logistics functions at fewer locations. This process has created "mega" operating bases such as the Ramstein-Kaiserslautern complex in Germany and the massive Joint Region Marianas centered on the Navy and Air Force facilities on Guam. While more efficient, these concentrated nodes present juicy targets, and subsequent disruptions can have massive, cascading impacts across the joint logistics enterprise.

In wargames, Chinese and Russian red teams launched huge attacks against key U.S. overseas bases. In Pacific wargames, Chinese red teams repeatedly exploited U.S.

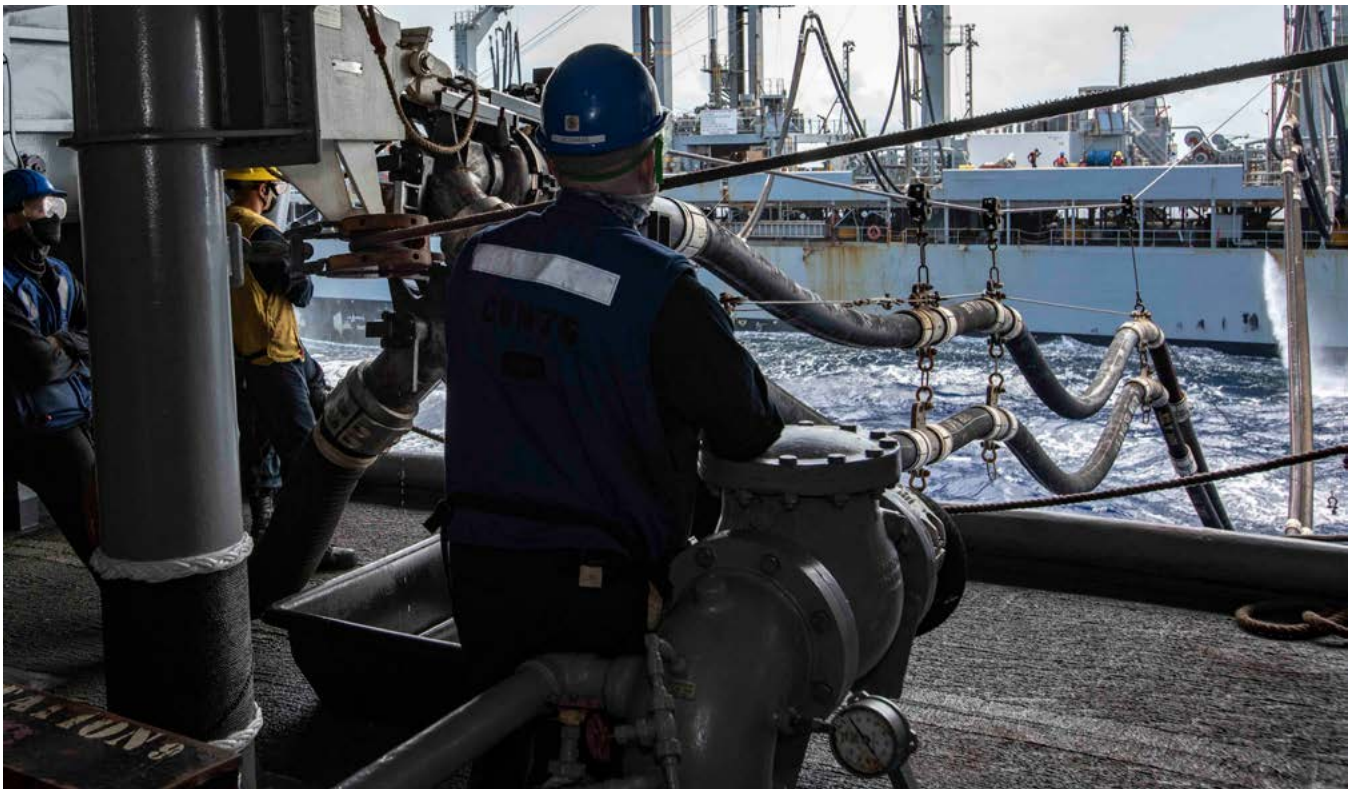


Much as Pearl Harbor (left) concentrated U.S. military power in ways that encouraged a Japanese first strike in 1941, Apra Harbor (right) and the broader military complex on Guam present a similarly tempting target for preemptive Chinese attacks today. (U.S. Navy and Jeff Landis/U.S. Navy)

dependence on Guam as a logistical hub. In addition to Guam, Chinese red teams attacked logistics operations in Japan, Australia, and temporary operating locations such as Palau. In European theater wargames, Russian red teams used a more selective approach to attack U.S. posture. This approach reflected the vast number of potential logistical sites in Europe as well as Russia's more limited long-range strike arsenal. The Russian red team's focus on attacking dual-use infrastructure nodes such as ports, airfields, and railway junctures also aligned with Russia's notion of strategic operations to destroy critically important targets with both civilian and military uses.[13]

Alongside posture, logistics information and command networks would likely be some of the highest-priority targets for Chinese and Russian counterlogistics efforts. These networks allow U.S. logisticians to assess logistical readiness and manage resources. Orchestrating the storage, maintenance, and movement of vast quantities of items on a global scale is an incredibly data-intensive process.[14] Over the last 30 years, U.S. logisticians have digitized their information systems to enable leaner "just-in-time" approaches that shrink inventories, save money, and achieve greater cost-efficiency.[15] While largely successful at automating and streamlining the management of U.S. logistics, this effort opened the joint logistics enterprise to cyberattacks.[16] In fact, because logistics organizations must share information with a wide variety of commercial businesses with inconsistent cybersecurity, these networks are uniquely vulnerable to enemy attacks.[17]

In wargames, Chinese and Russian red teams continually exploited the vulnerability of logistical information and command networks to disrupt the ability of U.S. "blue teams" to support and sustain operations. The effects of such attacks in real life would be magnified by the tightly choreographed nature of U.S. logistical operations such as aerial refueling. These operations have tight timelines and tolerances, so seemingly minor perturbations can cause massive disruptions. Exploitation attacks against vulnerable logistics networks could also provide critical intelligence to adversaries during a crisis or the early days of a conflict. During that period, U.S. logisticians would be pressing hard to gather information about their forces' readiness and the logistical state of the potential combat theater. This information would be invaluable to an adversary, as it would give the enemy a clear picture of



U.S. carrier strike groups, such as the USS Ronald Reagan's *Group 5 shown here in the Philippine Sea, depend on Combat Logistics Force ships for resupply at sea. Chinese planners understand this dependence and would likely prioritize attacking these vulnerable logistics ships rather than heavily defended carriers. (Quinton Lee/U.S. Navy)*

U.S. forces, including potential logistical constraints and weaknesses that might shape U.S. operations.

Attacks on the critical connectors that carry forces and materiel constitute the third major Chinese and Russian threat to U.S. logistics. These connectors consist of:

- Air Force transports and aerial refueling tankers;
- The Navy's Combat Logistics Force, maritime pre-positioning ships, and surge sealift forces, as well as the strategic sealift fleets of the U.S. Department of Transportation's Maritime Administration; and
- Army heavy trucks, such as the Heavy Equipment Transport and Heavy Expanded Mobility Transport Truck, and trains.

In wargames, Chinese and Russian red teams prioritized targeting aerial refueling tankers and underway replenishment ships. Chinese and Russian red teams viewed U.S. air power as their paramount threat at the outset of conflict. They therefore focused on destroying aerial refueling tankers and the replenishment ships that provide fuel and munitions to U.S. air bases and carrier strike groups.

The final Chinese and Russian threat to U.S. logistics comprises attacks on personnel, and particularly U.S. Air Force ground crews. Such attacks would exploit the personnel-intensive character of air-base operations by attacking the personnel directly, or by forcing the Air Force to abandon major bases in favor of dispersed forward operating locations. In wargames, red teams believed that this would be an effective way of crippling or limiting U.S. air operations, since U.S. ground crews would already be under strain from the high tempo of combat operations. Throughout this project experts identified a lack of qualified ground crew personnel as one of the most serious constraints on the ability of the Air Force to sustain operations under fire, or to adopt a more dispersed basing posture.

Wargames and analysis suggest that the cumulative logistical impacts of Chinese or Russian attacks could be severe. In Indo-Pacific theater games, Chinese red team attacks on logistics paralyzed U.S. operations. Without adequate fuel, munitions, maintainers, or functioning runways, U.S. blue teams could only generate small numbers of sporadic fighter aircraft sorties. Blue teams found themselves with limited response options consisting mostly of submarine attacks and large flights of bombers launched from bases in the continental United States. While effective, submarine and bomber attacks were not decisive in the wargames. In an actual conflict, such attacks could not be sustained for operations lasting weeks or months given the limited number of platforms and munitions available in the 2030 timeframe.

In European wargames, Russian red teams used a wide variety of means to create a gantlet of diversions, delays, detours, and disruptions. Preferred ports of debarkation were unavailable to blue teams due to mining, Russian missile attacks, clandestine operations (e.g., provoking strikes and walkouts by longshoremen), or cyberattacks on critical machinery. Railways and roads were likewise clogged or disrupted by all manner of Russian attacks. Russian missile attacks targeted warehouses full of pre-positioned equipment or staging locations, causing attrition, disruption, and—crucially—delays.

These attacks prevented U.S. blue teams from achieving the rapid movement of forces and materiel necessary to defend the Baltics. The outcome of these games suggests that U.S. force deployments and sustainment would face considerable delays and difficulties in a future Russia-NATO conflict.

In addition to directly threatening U.S. logistics, Chinese and Russian operational concepts and capabilities—especially long-range precision-guided weapons—indirectly hinder logistics by pushing U.S. forces to adopt dispersed and disaggregated operational concepts.[18] Dispersing and disaggregating forces can make them harder to target and increase their resilience to precision attacks. Unfortunately, there are two logistical drawbacks to this approach. First, the limits of physics and geography combined with the desire for cost-efficiency tend to concentrate logistical systems. The large, vulnerable, high-signature assets such as air bases and replenishment ships that result from these constraints are not easily dispersed or disaggregated and therefore present tempting targets. Dispersal may therefore help tactical forces evade or withstand long-range precision attacks, but adversaries can thwart this approach by attacking "upstream" logistical concentrations. Second, dispersal and disaggregation increase strains on logistics units, as they must cover greater distances to support the same number of forces or must break into smaller, less efficient subunits.

In future conflicts, these Chinese and Russian challenges to logistics, direct and indirect, would likely push the overstrained and under-resourced joint logistics enterprise beyond its breaking point. Using these threats as a guide, the following section lays out a concept for logistics that can adapt to threats and the need to operate in new and more logistically challenging ways.

Adaptive Logistics

The fundamental problem U.S. forces face in a possible conflict with China or Russia is not the overall quantity of U.S. forces, what the defense community calls "capacity." In most relevant metrics, U.S. forces have greater total capacity than either China or Russia. Nor is the problem one of quality—what the defense community calls "capability." Despite some notable exceptions, U.S. equipment and personnel are generally of superior quality to their Chinese and Russian counterparts.

Instead, the real problem facing U.S. forces, and, by extension, U.S. security policy is that U.S. forces are spread out across the globe and it takes a long time and enormous logistical effort to get them into the fight and sustain them once there. Decades of wargaming, analysis, and empirical evidence suggest that attacking these logistical dependencies in the ways described in the previous section is the most effective way of fighting the United States.

Future Indo-Pacific or European commanders cannot afford to have their forward sustainment systems go offline or operate at limited capacity for days or weeks at a time, while crucial reinforcements and supplies suffer weeks of delays getting into the fight. Blunting Chinese or Russian aggression will require resilient sustainment capabilities that can support combat operations in contested environments while degraded and damaged. Reinforcing the theater to push for conflict termination on favorable terms will require rebuilding and rebalancing strategic lift capabilities as well as devising new schemes of maneuver that focus as much on enabling logistics as on supporting offensive operations.

The problem facing the United States is that its forces are spread out across the globe and it takes a long time and enormous logistical effort to get them into the fight and sustain them once there.

This following section outlines an adaptive logistics concept that can serve as a framework for building a joint logistics enterprise capable of operating in highly contested environments. Adaptive logistics is not a replacement for traditional logistical methods across an entire campaign. Instead, it is a temporary, conditions-based concept for contested and degraded environments. An adaptive joint logistics enterprise would be capable of switching from efficient methods to resilient methods depending on threats, the character of U.S. operations, or the status of U.S. logistical networks.

At its core, adaptive logistics moves away from the traditional notion that the three major sections of the logistical system—the homeland, the zone of communications, and forward bases—function like a conveyor belt to bring forces and materiel into the fight and sustain it once there. At the beginning of a conflict, when operations are most contested, these sections will instead operate mostly independently. The remainder of this section describes each geographic portion of adaptive logistics in turn, beginning with forward operations, then intermediate basing operations, and then the role of the homeland as a base for global operations. The section concludes by discussing how adaptive logistics will require shifting between "push" and "pull" logistical models.

Contested Forward Logistics

Sustaining combat operations in contested environments such as the western Pacific or Baltic will be the most difficult logistical challenge facing U.S. forces in a war with China or Russia. Forces operating forward in these theaters are under myriad threats and at the end of long, vulnerable lines of communication. The 2018 National Defense Strategy adds to this challenge by requiring forward "blunt layer" forces to delay or deny adversaries from achieving their strategic objectives, thereby enabling a counterattack from a position of strength. The character of "blunting operations" envisioned in the strategy depends on the conflict scenario and the state of U.S. forward posture. However, one constant holds across a diverse set of scenarios and assumptions: Reinforcements take too long to arrive from the United States or other theaters to defend allies and partners or counterattack from a position of strength. To buy time by blunting adversary aggression, forward forces must survive and sustain operations to present a credible threat to adversary forces at the outset of a conflict.

The Joint Force wields substantial quantities of long-range weaponry, and these capabilities have grown over the last several budgets and will likely continue to grow as new systems designed for the current operating environment join the force.[19] Despite these investments, long-range attacks are unable to completely substitute for the combat power provided by forward forces in the 2030 timeframe. The volume of potential targets in a China or Russia scenario dwarfs the projected capacity

Long-range strike bombers, such as the B-2 shown here refueling over Guam, can fly directly from the United States to strike targets in combat theaters. Unfortunately, the small number of bombers, logistical constraints, and the duration of these flights limit their ability to sustain high-tempo operations. (Jazmin Smith/U.S. Air Force)

of U.S. long-range weaponry. This means that the most advanced long-range weapons, such as the joint air-to-surface standoff missile, would be reserved for critical targets such as command-and-control nodes. Operating from longer ranges also strains logistical systems such as aerial refueling. For example, delivering the same quantity of fuel at 3,000 nautical miles from a base of operations requires five KC-46A refueling tankers, compared with just one tanker at 1,000 nautical miles.[20] Moreover, assembling, planning, and launching long-range attacks is time, personnel, and resource intensive and therefore difficult to sustain at a high tempo. In wargames, this means that U.S. long-range attacks tended to come in big, predictable waves. Over time, red teams in these games learned to feint to provoke these waves, then hunkered down or retreated to withstand or avoid the attack before emerging to seize their objectives after the wave receded.

Credible forward forces are therefore indispensable to bring the mass and persistent tempo needed to blunt adversary aggression. The challenges facing Indo-Pacific and European commands are keeping these forces alive during the initial onslaught of precision attacks, then sustaining their operations over time. To meet these challenges, contested forward logistics comprises three shifts: moderating operational tempo, pre-positioning equipment and materiel, and living off the land.

MODERATING OPERATIONAL TEMPO

Ideally, U.S. forward forces could sustain high-tempo combat operations for long enough that, in conjunction with long-range capabilities such as land-attack missiles and cyberattacks, they could stymie an adversary's offensive. Unfortunately, wargames and analysis suggest that logistical constraints would likely limit what forward forces can contribute to the fight, at least in the opening days and weeks of a conflict. In these cases, U.S. forward forces can contribute more to the fight by doing less and evading destruction, rather than attempting to sustain combat operations, thereby exposing themselves to attrition. Forward-based forces—and particularly short-range tactical aircraft—will have a key role in a protracted conflict with China or Russia. To play that role, they must avoid being destroyed early.

This "force-in-being" approach proved effective in wargames. U.S. forces in Japan demanded constant attention from Chinese red teams, even if their offensive contributions were minimal. By simply staying alive and conducting flight operations, they required Chinese red teams to concentrate on suppressing or destroying them. Moreover, by presenting a persistent, dynamic target set, these forces encouraged Chinese red teams to push their intelligence, strike, and escort aircraft into defended Japanese airspace, thereby risking greater aircraft attrition to fighters or surface-to-air missile systems.

A similar dynamic applied to U.S. ground forces in the Baltics during European games. Maneuvering to stay in the fight was preferable to attempting a static forward defense. Although not ideal, blunting aggression by fighting a delaying action is better than dying in place or being quickly bypassed and rendered combat-ineffective. A fighting retreat also has the benefit of allowing forces to fall back on their logistical lines of communication, rather than stretching them or being cut off altogether.

Restraining operations to preserve forces and logistical capacity during high-intensity combat operations may seem counterintuitive, but it aligns with one of the core findings of this report: Logistics should not be subordinate to combat operations in planning or execution. A later section will discuss the importance of better integrating logistics into operational planning, but the key point here is that combat operations must conform to logistical reality, rather than demand logistical support for unrealistic courses of action. The former may be disappointing, but the latter is a potential disaster.

This rendering of the Army's pre-positioned Stock 2 location in Powidz, Poland, illustrates how concentrated and vulnerable to Russian attack these large, fixed facilities could be in future conflicts. (U.S. Army)

PRE-POSITION FORCES AND MATERIEL

In future conflicts with China or Russia, forward bases will be disrupted or disabled and resupply from rear areas will be delayed or limited. Pre-positioning can be an effective means to reduce dependence on forward bases and resupply from rear areas, provided that the pre-positioned stocks are accessible, distributed, secured, and properly maintained. Wargames highlighted this need for security and dispersal—any concentration of pre-positioned stocks or unit equipment sets, such as the Army's Pre-positioned Stocks or the Marine Corps' Maritime Pre-positioning Squadrons, became easy targets for Chinese or Russian long-range strikes. Smaller, more distributed materiel and equipment sets are far less likely to be targeted, and more resilient to adversary attacks, but they also create enormous demands for logistical personnel to emplace, track, maintain, and exploit them.[21]

One possibility is creating forward caches of precision-guided munitions. Another is creating mobile munitions trucks to avoid adversary targeting. While some munitions require regular care and inspections, making it difficult to cache or relocate them, U.S. forces have experience with long-term pre-positioning of munitions with relatively little maintenance. Munitions Activities Gained by Negotiations Between U.S. Air Force/Republic of Korea Air Force Memorandum of Understanding, commonly known as MAGNUM, are U.S. Air Force weapons stored at Republic of Korea Air Force facilities and maintained by Korean personnel.[23] According to experts, these munitions can remain in storage with inspections every one to two years. Improvements in munitions technology have also allowed development of weapons that require far less maintenance than early generations of precision-guided munitions.

Pre-positioned equipment and materiel can improve the mobility and sustainability of U.S. forces, but only with secure storage and an ability to marry forces rapidly and securely with their equipment. Pre-positioned stocks should be close enough to potential combat that they enable U.S. forces to get into the fight quickly, but not so close that U.S. forces are vulnerable to attack while falling in on their equipment. In Baltic wargames, for example, Russian red teams attacked pre-positioned equipment in Poland and Germany but ignored sites in western Europe, figuring those forces were too distant to matter and beyond the range of their most numerous and capable strike systems.

One potential solution is to draw on the Cold War example of "pre-positioned organizational materiél configured to unit sets," more commonly known as POMCUS.[24] As the name implies, these prepositioned stocks were configured and maintained so that personnel could quickly fall in on their equipment and fight. An updated version of these sets—possibly as small as company- or platoon-sized elements—could be distributed to hidden sites in Poland or the Baltic republics, allowing for rapid but resilient mobility.

FIGURE 2: CURRENT PRE-POSITIONED STOCKS[22]

U.S. Marine Corps Prepositioning Programs

Army Base

U.S. Air Force Pre-positioned War Reserve Materiel (USAF PWRM)

	DESIGNATION	MATERIALS Unit Sets	OPROJ	SUSTAINMENT
APS-1	Continental U.S.		■	■
APS-2	Europe	■	■	■
APS-3	Afloat	■	■	■
APS-4	Indo-Pacific	■	■	■
APS-5	Southwest Asia	■	■	■
APS-6	U.S. Army South		■	
APS-7	U.S. Army Africa		■	■

	USAF PWRM LOCATION	MATERIAL CSE	FSE	BEAR
	Continental U.S.	■	■	■
	Europe	■	■	■
	Afloat	■		■
	U.S. Indo-Pacific	■	■	■
	Central Command	■	■	■

APS	Army Pre-tpositioned Stock	BEAR	Basic Expeditionary Airfield Resources
OPROJ	Operational Project Stocks	MPSRON	Maritime Pre-positioning Ship Squadron
CSE	Common Support Equipment	MCPP-N	Marine Corps Pre-positioning Program Norway
FSE	Fuels Support Equipment	PWRM	Pre-positioned War Reserve Materiel

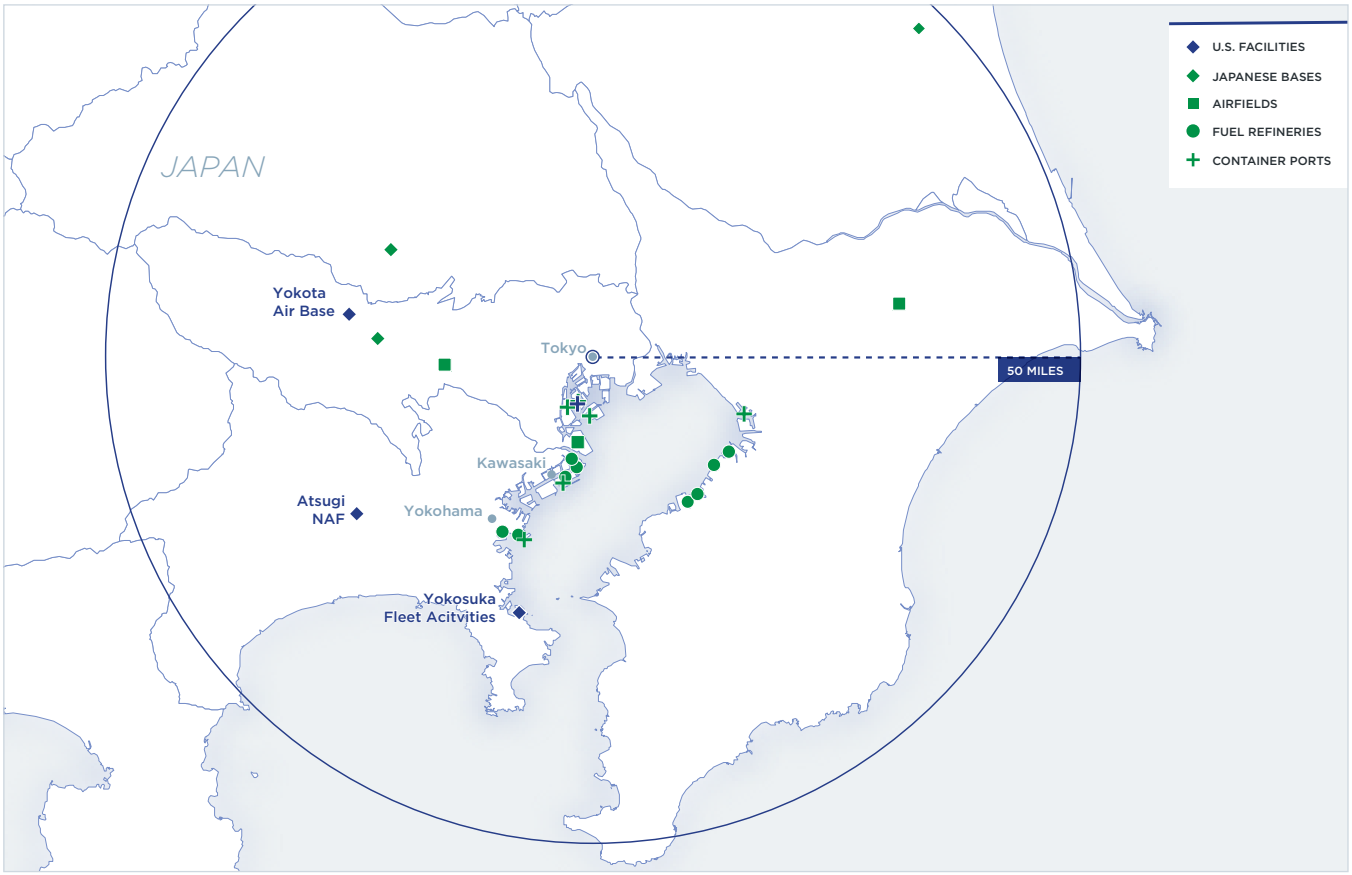
The Defense Department has pre-positioned equipment and materiel at sites around the globe to improve its ability to respond to crises. As shown here, however, these sites are concentrated and geographically misaligned with current strategic priorities.

LIVE OFF THE LAND

In addition to pre-positioned stocks, U.S. forces operating forward in highly contested environments must learn to "live off the land" by locally acquiring fuel and petroleum, oils, lubricants, water, food, construction materials, and general spare parts. Wargames suggest that the joint logistics enterprise will struggle to bring such bulky supplies to forces operating inside contested environments during the opening days and weeks of a conflict. Specialized military fuel and petroleum products proved the most problematic, as these are typically delivered with large tankers through major ports, both of which are vulnerable to interdiction. The Military Sealift Command has two "offshore petroleum distribution system" ships that can pump fuel from tankers directly over the beach without need for fixed on-shore facilities, but these ships would likewise be vulnerable to attack.[25] Rather than rely on external fuel resupply, forces operating forward should stockpile additives needed to modify civilian fuels such as Jet A/A-1 into JP-8 military jet fuel.[26] This would allow forward forces to rely on widespread and relatively resilient civilian fuel production and distribution networks. While these supplies would not be inexhaustible and might require augmentation to handle military traffic, they could provide significant additional capacity and resilience when added to U.S. military fuel stockpiles and distribution systems.

Closer integration of U.S. military logistics systems with those of allies and partners will enable them to live off the land and minimize their reliance on external resupply and vulnerable infrastructure. As the armed service most dependent on fixed infrastructure, the Air Force is exploring and exercising concepts such as Agile Combat Employment that would allow it to operate from allied and partner bases or commercial airfields.[27] In some cases these operations could use pre-positioned munitions and equipment. In others, the Air Force might fly equipment, materiel, and personnel in on cargo transport alongside combat aircraft, thereby requiring almost no permanent U.S. footprint.

FIGURE 3: CONTESTED FORWARD LOGISTICS IN JAPAN



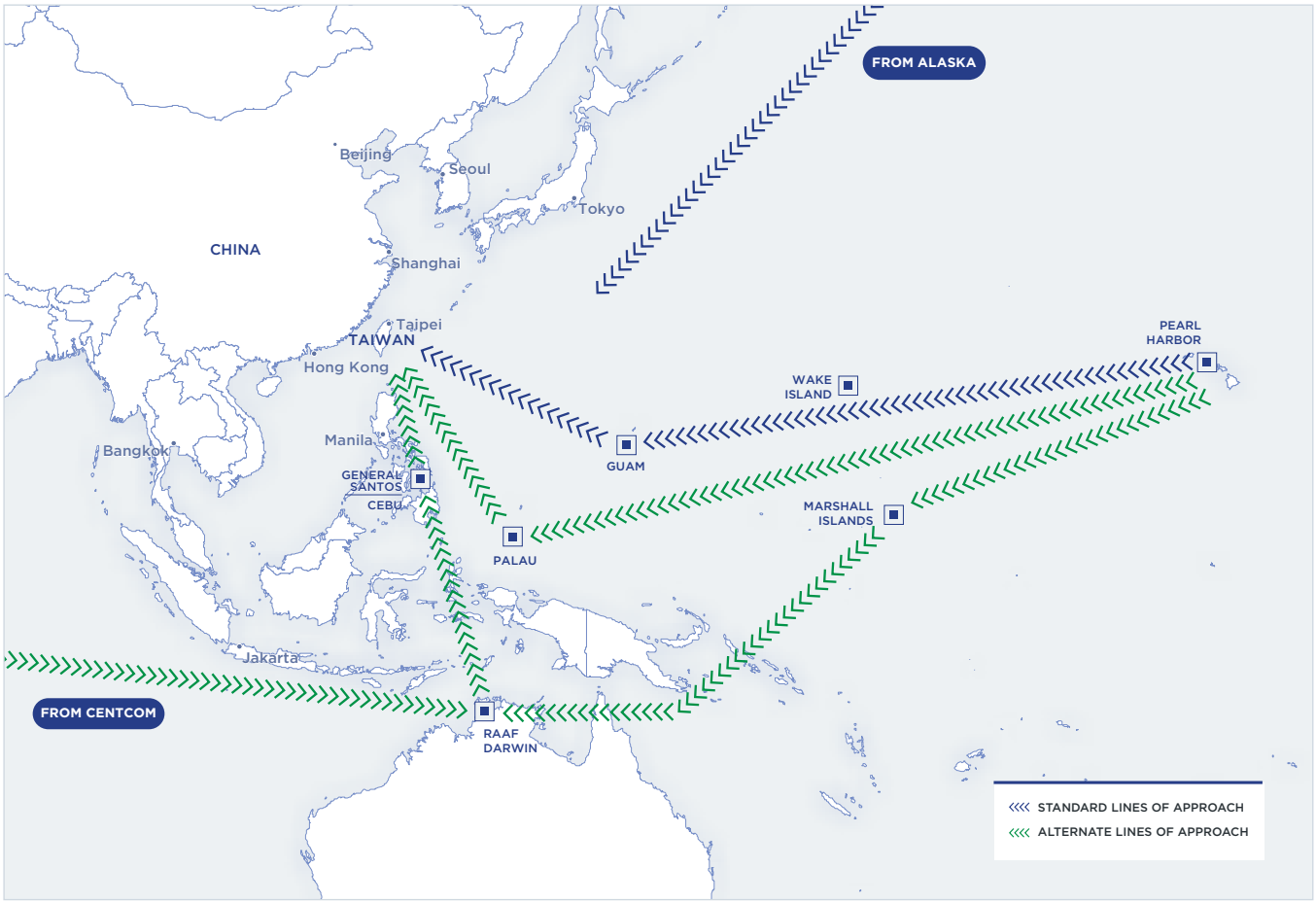
This map shows options available for creating a more resilient basing and logistics posture within 50 miles of Tokyo. Japanese military and commercial airfields can disperse aircraft and ground support equipment. Refineries and commercial fuel storage can supply fuel. Ports and warehouses can manage cargo or prepositioned stocks.

Intermediate Basing Operations

In adaptive logistics, bases and geographic areas farther from China evolve from being zones of communication to being bases for offensive strikes and maneuver. The purpose of intermediate basing operations is several-fold. First, it enables a more defensible basing and logistics posture for offensive actions against the adversary from the outset of the conflict. While not as responsive as forward bases, this zone would provide a quicker and more consistent operations tempo than bases in the United States. Because of its greater range from the most dangerous threats, this zone can host critical logistics functions such as maintenance facilities that may be impossible to protect farther forward. For example, this zone might support aircraft maintenance that could not be conducted at distributed forward bases. This zone would also be where Navy surface vessels and submarines would come to reload their vertical launch system cells, and where underway replenishment ships would resupply from ports, shuttle ships, and consolidated logistics tankers.[28] Additionally, the more defensible bases in this zone could host aerial refueling tankers to support offensive operations from this zone, or from the continental United States.

The next function of intermediate base operations is to support multiple, defensible lines of communications for bringing forces and materiel to forward locations. Adaptive logistics is intended to support combat operations during the opening weeks of a conflict while operating environments are most heavily contested and degraded. Wargames suggest that the moment traditional logistical forces enter contested environments might be perilous if the Joint Force does not take necessary precautions. Chief among these is establishing multiple, defensible lines of communication from relatively secure rear areas to forward locations. In wargames, Chinese and Russian red teams had little difficulty disrupting and degrading single lines of communication, such as that

FIGURE 4: MACARTHUR'S REVENGE



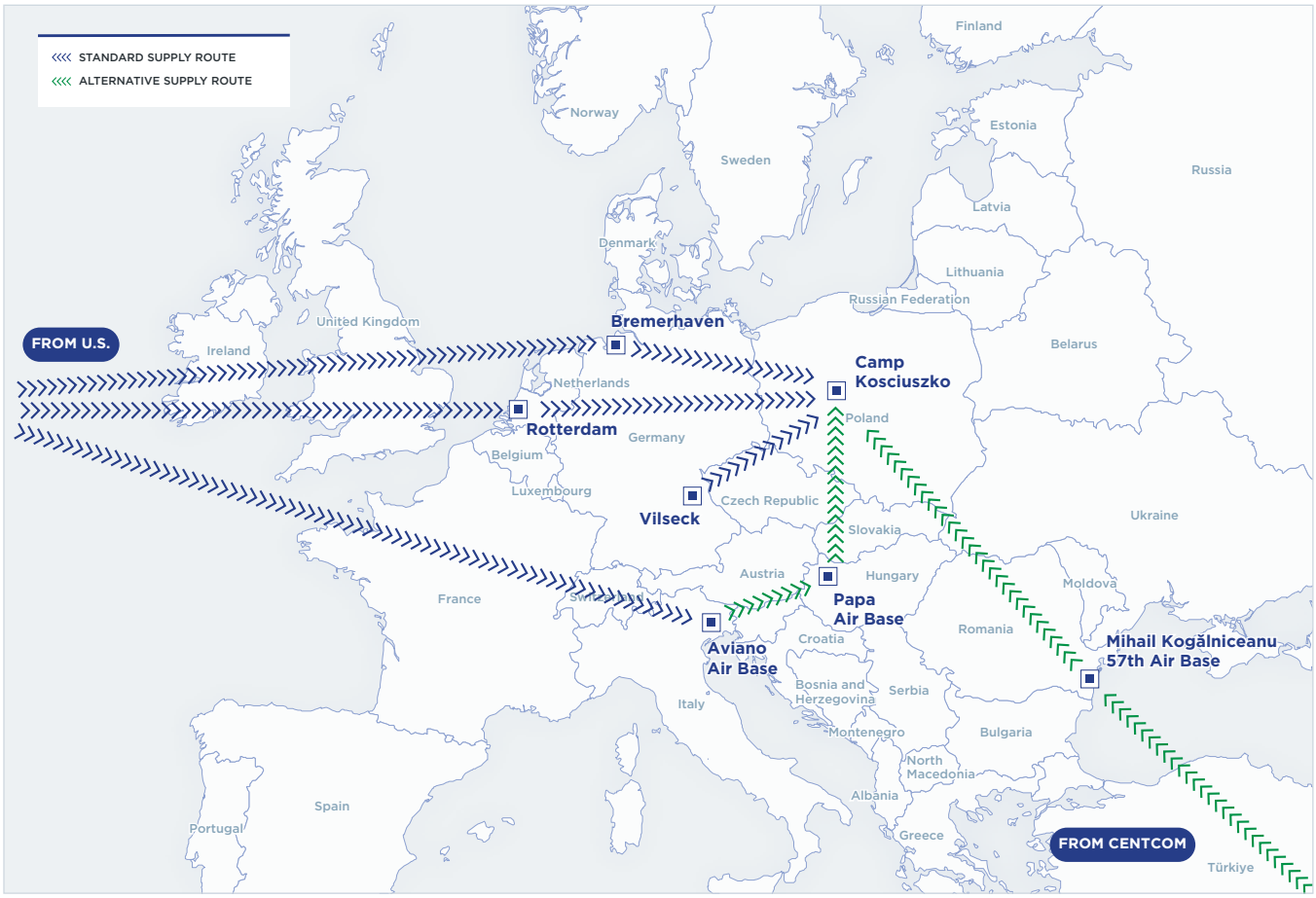
This figure alludes to General MacArthur's maneuver through the Southern Pacific in World War II. It shows an alternate, more defensible scheme of maneuver and support using Australia as a logistical hub. Forces and materiel flow through locations in the Southeast Asian archipelago, which are defended by Marine Littoral Regiments and Army Multi-Domain Task Forces.

from Guam to Japan, or across northern Europe to the Baltic region. Establishing multiple lines of communication could prevent China or Russia from choking off logistics by striking a handful of fixed facilities or by lying in ambush along a single line of communication.

Wargames also suggest that U.S. forces should use maneuver and fires to enable logistics in a reversal of the traditional role of logistics supporting maneuver and fires. In Pacific wargames, blue teams successfully executed a scheme of maneuver called "MacArthur's Revenge." This tongue-in-cheek name refers to the dispute between General Douglas MacArthur and the Army on one hand and Admirals Chester Nimitz and Ernest King and the Navy on the other over the proper course of Pacific operations in World War II. Like MacArthur, the U.S. teams used Australia and the Philippines to provide bases of supply and defensible, resilient lines of communications. This scheme also enabled U.S. forces and supplies from Europe and the Middle East to flow more securely from the Indian Ocean and points farther west, rather than transiting the highly contested South China Sea via the Strait of Malacca. The terrain of the Philippines allowed Marines, supplemented by Army fires and air and missile defenses, to protect ports and logistical ships without heavy reliance on escorts. As during Army operations in World War II, U.S. forces and materiel would need to flow through the southern portions of the Philippine archipelago using ports such as Tacloban on the Leyte Gulf, as northern ports like Subic Bay would be too contested.

U.S. blue teams in European wargames used a similar approach after the difficulties encountered using a single, direct line of communications across northern Europe. Using the Mediterranean and Italian bases as a starting point, this additional route avoided the densest missile threats emanating from Kaliningrad and opened the possibility of flanking maneuver against Russian forces in the Baltics.

FIGURE 4: DRAGOONED



Similar to how Operation Dragoon created a second avenue of maneuver and support during the Allied invasion of France in 1944, this figure shows how a second axis of mobility and support through southern Europe can bypass some of the densest Russian threats, avoid logistical bottlenecks, and open opportunities for flanking maneuvers.

Regardless of scenario, the lesson from wargames is clear: U.S. forces must prepare multiple defensible logistical lines of communication, particularly in the most contested environments. This will require operational planners to design schemes of maneuver and strike plans around establishing and defending these lines, rather than the other way around as is typical.

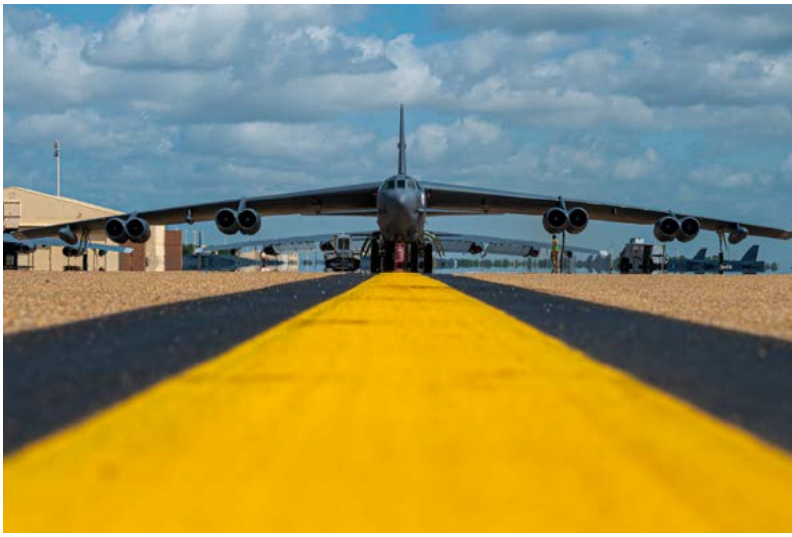
The Homeland

The homeland will become a critical base for global strike operations in any campaign against China or Russia. While the homeland will not be a "sanctuary," wargaming and analysis suggest that China and Russia may be hesitant to strike the United States, and particularly the continental United States, given the potential for escalation. This fear, combined with China's and Russia's relative lack of conventional global strike systems in the 2030 timeframe, suggests that the homeland should be a relatively secure base for strike operations. In wargames and analysis, bombers launched from the homeland, along with submarines, proved the most potent U.S. weapons systems. Their ability to deliver large, concentrated salvos of precision-guided munitions enabled them to saturate defenses and maul adversary maneuver forces, whether amphibious shipping in the Taiwan Strait or mechanized forces in the Baltic region.

Two factors inhibited the U.S. bomber fleet from achieving decisive effects in the game. The first was the availability of critical munitions, such as long-range anti-ship missiles, or joint air-to-surface standoff missiles. In every single wargame, U.S. offensive striking power dropped off a cliff after the limited stockpiles of these critical munitions were depleted. The Defense Department has taken steps over the last four years to increase the number of these weapons available to the force, but they remain a key limiting factor, both logistically and operationally. This lack of weapons capacity also calls into question various Air Force and Navy initiatives to increase offensive strike capacity by adding weapons launchers to cargo transports and auxiliary surface vessels. U.S. armed forces today lack enough munitions to load out current combat units, so adding more vertical launch cells to the Navy or munitions-carrying capacity to the Air Force without solving the munitions shortfall will not increase overall strike capacity; it will instead cause U.S. forces to exhaust their weapons inventory faster. Once exhausted, this inventory cannot be replaced quickly. These weapons are complex to produce and, after decades spent pursuing cost-efficiency for peacetime production, the munitions industrial base has no spare capacity to surge production.[29]

The second factor limiting the effectiveness of the bomber fleet is time and its close relative, tempo. Operating from range improves the security and reliability of basing and logistical support, but it increases the time aircraft spend in the air flying from their base to the mission area and back. For example, flights from Barksdale Air Force Base in Louisiana—which hosts B-52s—to the vicinity of Taipei would be roughly 33 hours round trip without any time to loiter in the target area.[30] Depending on various assumptions about crew rest or swapping, and the degree of maintenance and mission planning required, the aircraft would likely spend at least 12 hours on the ground before heading back out on another sortie.[31] This means that bombers based in the continental United States could optimistically launch one sortie every 48 hours, and it is unlikely that such a rapid tempo could be sustained.

Limited bomber availability presents U.S. commanders with a dilemma, particularly in the early stages of a conflict when long-range assets would carry the bulk of offensive operations. Commanders can launch large numbers of smaller strike packages spaced over time. This has the advantage of sustaining strikes, thereby denying the adversary windows of time when their forces are relatively unthreatened. These smaller packages can also arrive from multiple different axes of approach, although there are limitations based on aerial refueling availability and basing. The downside of streaming smaller strikes over time is that it presents defenders with an easier challenge. Shooting down 200



The B-52H can carry a prodigious amount of munitions over ranges exceeding 7,600 nautical miles (14,000 km). However, long flight times from U.S. bases such as Barksdale Air Force Base in Louisiana limit its ability to maintain that striking power in a combat theater like East Asia. (Kate Bragg/U.S. Air Force)

missiles in 10 salvos of 20 missiles spaced out over time is far easier than shooting down a massed salvo of 200 missiles, for example. Smaller strike packages also strain the ability to provide each with escort fighters, electronic warfare support, and aerial refueling. These constraints increase the chances of U.S. attrition to weapons or platforms, thereby decreasing the impact of each strike. Alternatively, commanders can launch large, concentrated salvos with the aim of overwhelming defenders. Large strike packages are more likely to hit their targets, as salvos saturate missile defenses, allowing weapons to leak through. The downside to this approach is that it limits the geographical and temporal scope of attacks.

In wargames, U.S. blue team commanders generally opted for "gorilla packages" comprising large numbers of bombers escorted by fighters, electronic warfare assets, and other support aircraft. These packages suppressed and saturated adversary defenses, delivering devastating firepower against their targets. Unfortunately, blue teams only had enough resources to generate one of these packages per day. As devastating as these attacks were, their sporadic, "pulsed" tempo, combined with the long duration of these missions, allowed red teams to mitigate their effects or deceive U.S. forces. For example, Chinese red teams invading Taiwan feinted launching their cross-strait invasion to prompt the U.S. blue team to launch a massive strike package. When the bombers arrived at their launch points, they found only decoys and commercial transports loaded with political prisoners.

The Air Force needs to reorient its U.S.-based bomber operations toward sustained global conventional strike operations, rather than the limited, predominantly nuclear strike operations for which they are currently optimized. This should include increased munitions stockpiles, rapid availability of aerial refueling tankers, increased aircrew and ground crew capacity and readiness, and technologies to allow for faster weapons loading and refueling. Air Force Global Strike Command should consider a "zero-to-sixty" concept, in which it maintains sufficient readiness in its bomber force, personnel, and associated logistical assets such as refueling tankers to generate 60 conventional bomber sorties in the vicinity of Taiwan or the Baltic region on "zero day," or the start of a conflict. Ultimately, the Department of Defense should use a sustained global strike concept to assess the size of its bomber force and supporting logistical assets, which may need to grow relative to the size of fighter forces.

U.S. air planners prefer to launch "gorilla packages" of bombers, escort fighters, and other assets to increase aircraft survivability and the probability of mission success. Even with allied support, as in this combined U.S.-Japan exercise near Okinawa in February 2022, there simply are not enough assets to create many of these packages. (Yosselin Campos/U.S. Air Force)

Push and Pull

Information is the currency of logistics. It enables logistical supply to meet operational demand. Without accurate and timely information, logistical systems underperform or break down altogether. The current "pull" model U.S. forces use to command logistical operations is poorly suited to the demands of combat against China or Russia, which possess the ability to disrupt and degrade information and command networks. The use of dispersed operating concepts only exacerbates the inadequacy of the pull model, by creating multiple, diverse, and geographically distributed demand signals that overwhelm the processing capacity of current logistical systems designed for peacetime operations.

U.S. logistics predominantly use "pull" or "just-in-time" systems in which operational forces request support and supplies, and logisticians fulfill these requests.[32] Done correctly, this model can be more efficient than "push" systems, in which logistical forces send support and supplies out on a schedule based on predicted demand. By only supplying what forces need, when they need it, pull systems can be leaner, with smaller inventories and less demand for storage and transport. They can also be more responsive to the vagaries of combat. Demand for some forms of supply—food, water, and personal supplies, for example—is relatively steady in peace or war. Demand for other items, such as fuel and certain types of ammunition, rises and falls at relatively predictable rates based on operational tempo. Other needs, though—long-range precision-guided munitions, critical spare parts, and major end items such as missile launchers or vehicles—are much less predictable. By relying on units to report their needs and by (ideally) quickly fulfilling them, pull systems reduce shortfalls, bottlenecks, and pileups in the supply system that can happen under push logistics, when items are sent forward regardless of actual demand.

There is a catch. The responsiveness and efficiency of pull systems require detailed knowledge of combat forces' logistical necessities and means to communicate these needs to logisticians. Collecting this information is difficult in peacetime, as it often requires individuals and units to accurately track and report supply statuses. Sometimes, this information is tracked well and reported clearly. More often, tracking and reporting are desultory efforts that lack the necessary precision or level of detail. As a result, logisticians, staff officers, and commanders lament that they spend more time collecting and compiling data than they do acting on it.

Fixing this problem is the impetus behind automated logistical data systems such as the F-35's erstwhile Autonomic Logistics Information System (ALIS) and its replacement Operational Data Integrated Network (ODIN), as well as such efforts as the Defense Advanced Research Project Agency's (DARPA's) LogX program.[33] These systems can enhance logistical responsiveness and accuracy by improving the speed and quality of information gathering. Once gathered, however, this information and the networks carrying it are prime targets for adversary cyberattacks.[34]

Adaptive logistics demands shifting between responsive and efficient pull models, and more robust and sufficient push models. These shifts will depend on three conditions: 1) threats to logistical forces and infrastructure, 2) disruption of logistical information and command networks, and 3) U.S. operational tempo and dispersal. Enabling this shift will require capabilities or strategies to mitigate or hedge against gaps in knowledge of logistical needs, as well as a resilient information architecture (outlined in a later section) that affords a comprehensive view of logistical operations in relation to combat operations—i.e., a common logistical picture integrated with a common operating picture.

If the Defense Department develops data-driven and artificially intelligent logistics systems, it should do so with an eye toward increasing resilience rather than efficiency.

Phases of conflict or geographic locations in which adversary threats are acute might require using push rather than pull logistics. Instead of sending supplies forward on request, it may be necessary to send them forward during windows of opportunity, such as gaps in adversary targeting. A historical example of this kind of opportunistic push logistics is the infamous "Tokyo Express," which used speed, audacity, and the cover of darkness to supply Japanese forces at Guadalcanal in World War II, despite allied interdiction efforts.[35]

Shifting to push logistics could help offset adversary disruptions of logistical information and command systems. Rather than waiting for requests for resupply, the logistical enterprise could sustain operations by pushing supplies forward proactively based on predicted demand. This would be less efficient than responding to unit requests, but it would ensure sufficient supplies to sustain operational tempo when networks and communications are disrupted.

Pushing supplies may also be necessary to keep up with high operational tempos. One downside of pull logistics is the delay between recognizing a requirement, reporting it, and receiving resupply.[36] During periods of intense combat in theaters as large as the Indo-Pacific or Europe, waiting days or weeks for additional fuel, munitions, or spare parts could cripple operations. Hedging strategies could include pre-positioning critical items in anticipation of requests, thereby reducing delivery times. Pushing supplies forward could create oversupply, but this inefficiency is far outweighed by the risk of a forward unit having to slow or cease operations for lack of supply.

Ideally, these pushes would comprise packages of fuel, munitions, and critical parts tailored to the specific needs of a given unit based on its operational status. The demand for such smart predictive push logistics is driving efforts to incorporate artificial intelligence into the joint logistics enterprise.[37] While well-intentioned, these efforts will likely be stymied by a dearth of usable data. Vast quantities of logistical data are collected by individuals and reported orally or handwritten on whiteboards. That is, if the data is collected at all. Using current systems and processes, gathering these kinds of data from across the joint force and then processing and cleaning it so it is ready for use in artificial intelligence systems would be inconceivably complex and time and resource intensive. If the Defense Department can solve this data shortfall and develop data-driven and artificially intelligent logistics systems, it should do so with an eye toward increasing the resilience of the joint logistics enterprise to degradation, rather than improving its efficiency as has historically been the case with such efforts.

Critical Components of Adaptive Logistics

Executing adaptive logistics will require changes and investments across four key areas of the joint logistics enterprise: posture, connectors, networks, and personnel. The following section will examine each of these in greater detail.

Posture

Without the three components of posture—footprint (bases and locations), forces, and access agreements—the U.S. military logistics system would not exist in its current form. Following Thomas M. Kane's formulation from *Military Logistics and Strategic Performance* that logistics determines the options available to a commander, posture determines the options available to the logistician. Aircraft need airfields, ships need ports, and ground forces need bases and transportation. More than any other factor, the structure of U.S. posture determines how the Joint Force carries out combat operations. The concentration of U.S. overseas posture and its lack of resilience constitutes one of the most worrisome vulnerabilities for U.S. logistics and U.S. operations more broadly in potential conflicts with China or Russia.

The solution to this problem is clear, but unpopular for many reasons: The U.S. government needs to invest money, time, and senior-leader attention toward developing a better, more diversified portfolio of posture options, particularly in the Indo-Pacific.

> **Logistics determines the options available to a commander; posture determines the options available to the logistician.**

The first step is to "harden" existing, plausibly defensible bases (e.g., Guam would qualify, but not Okinawa given its proximity to China) by adding active and passive defenses and making them more resilient by building in redundancy for key systems. The United States will likely never abandon major bases such as Guam or Ramstein. Their size and efficiency are simply too useful for peacetime operations. The key is to ensure that, during a conflict, adversary actions cannot shut these bases down for days at a time, thereby crippling U.S. logistics and combat operations.

Defensive efforts should be layered, complementary, and focused on protecting critical logistical assets such as fuel farms, pumps, weapons bunkers, loading cranes, shore power, and maintenance facilities. Taxiways and apron space at air bases should be expanded to enable them to serve as auxiliary runways while allowing greater dispersal for large logistical aircraft. Critical munitions should be stored in hardened and buried facilities. Harbors such as Apra should have the ability to rapidly reconstitute their maintenance and support capabilities while potentially performing salvage operations on damaged ships. In addition, major bases should be the focus of constant military deception and information operations. It may be impossible to hide them, but it may be feasible to conceal or obfuscate their status and occupants.

The second step is to develop a broader network of reliable and defensible bases and logistics nodes and to resource the equipment and personnel needed to operate from these locations. Reliable means that access to these

This electrical conduit powers fuel tanks on Guam holding almost 30 million gallons of fuel. It represents the type of infrastructure that should be hardened or made more resilient by building in redundancy. (Aubree Owens/U.S. Air Force)

bases will not be subject to the whims of mercurial political leadership (e.g., the Philippines), or fence-sitting during a U.S.-China conflict (e.g., Singapore). The most reliable locations for expanding posture options are U.S. territories such as the Marianas (e.g., Guam, Tinian, and Saipan), Wake Island, and states in compacts of free association with the United States (e.g., Palau, the Republic of the Marshall Islands, and the Federated States of Micronesia).[38]

The United States could also expand its footprint on the territory of reliable allies such as Japan and Australia. In Japan, given the geographic and political constraints, this could involve working with the Japanese government to establish "hoteling" agreements that allow U.S. logisticians to position equipment, materiel, and possibly small detachments of personnel at Japanese Self-Defense Force bases and civilian ports and airfields. These sites could create the basis for a resilient web of logistical support in Japan rather than the current, more concentrated U.S. posture at major bases such as Kadena, Yokota, and Misawa.

Though more distant from potential flashpoints in the East China Sea, Australia offers the same benefits that caused Allied military planners to view it as the crux of their position in Asia in World War II. Its geography straddles the Indian and Pacific Oceans. In the event of a conflict, it has more secure sea lines of communication and an abundance of space to host logistical hubs. The Pentagon should look to repurpose and expand its position in Darwin. Rather than being primarily a Marine Corps base, Darwin, Tindal, and other locations in northern Australia should transition toward becoming logistics hubs for U.S. and allied forces.

The third step involves placing a large number of riskier bets on access options that could prove useful in a contingency but which, on their own, would not form the backbone of U.S. posture and logistics. These locations could comprise a broad and diverse network of potential operating locations that would regularly host rotational U.S. forces but that would not necessarily host permanent U.S. forces or pre-positioned stocks. The Philippines is the most obvious candidate here, given its location, historical ties to the United States, close relations between the Philippine and American armed forces, and frustration with China over ongoing encroachment on Philippine maritime claims.[39] However, U.S. access in the Philippines has historically been subject to political upheaval. While the U.S. government should certainly

pursue broader access arrangements in the Philippines, it should avoid overreliance on access there. The next tier of candidates includes Indonesia, Malaysia, Vietnam, Brunei, and Thailand. These states have previously engaged in defense and security cooperation with the United States, albeit to varying degrees, and may be willing to host U.S. logistical hubs. Their willingness to allow U.S. forces access during a crisis or conflict with China, however, remains uncertain, hence their position in this highest-risk tier.[40]

The final step in building a more resilient logistics posture is to evolve U.S. force structure over time to limit dependence on large, fixed forward installations such as airfields and ports. As noted previously, the wargaming and analysis that informed this report suggested long-range strikes and submarines will play a central role in blunting Chinese or Russian aggression. However, the U.S. Joint Force of the 2030 timeframe will probably not have these weapons systems in sufficient numbers to replace forward forces. The Pentagon must invest more in these "access-insensitive forces," as defense strategist Jim Thomas calls them. Unfortunately, Thomas and other strategists have been arguing for shifting the Pentagon's portfolio of combat forces toward long-range systems and submarines for decades, to relatively little effect.[41] A more realistic approach over the next 10 years must argue for these portfolio shifts while also leveraging what the Pentagon has available or can acquire during that timeframe. This section therefore explores other ways to reduce U.S. dependence on vulnerable forward posture.

In every Indo-Pacific or European wargame conducted at CNAS over the last three years, U.S. blue teams have lost some degree of access to forward bases and logistical hubs. In every case, these teams fell back on nuclear submarines and long-range strikes from bombers to provide offensive firepower until they could reestablish functioning forward bases. In many games, particularly those in the Indo-Pacific theater, forces with no forward logistical footprint accounted for most successful attacks on adversary forces in the first weeks of a conflict.

FIGURE 5: A MORE RESILIENT INDO-PACIFIC POSTURE

A more resilient Indo-Pacific posture requires hardening and defending existing bases in the Second Island Chain and beyond; expanding access at bases in U.S. and close allied territory, including dispersal options in Japan and logistical stockpiles in Australia; and developing access options in high-risk but high-leverage locations such as the Philippines and Vietnam.

The heavy reliance on bombers and submarines to deliver fires is driven primarily by difficulties in generating tactical air power from forward air bases. These bases can generate enormous quantities of flexible combat power, but they are uniquely vulnerable in the opening phases of future conflicts with China or Russia. Some of these facilities and systems can be hardened, made redundant, or repaired, but the totality of U.S. forward air base posture remains vulnerable to systemic disruptions.[42] This vulnerability suggests that the methods and means of applying combat power must evolve, even as the Pentagon works to make bases more resilient in the interim.

Even with greater investments in long-range strike and submarines, the United States will still need forward-based, short-range air power for its responsiveness, affordability, and the signal that it sends to allies, partners, and

The USS Ohio (SSGN-726) *guided missile submarine, shown here with two dry-dock shelters during a port visit to Busan, South Korea, provides survivable firepower in contested environments. Along with its three sister ships, the* Ohio *will retire before 2030, taking its ability to launch 154 Tomahawk missiles with it. (Wesley Breedlove/U.S. Navy)*

adversaries. However, the character of the aircraft and the air base, along with their role in combat operations, will need to change. Increasingly, forward air power in the early days of a conflict will comprise low-cost, "attritable" unmanned systems that can launch from distributed locations or other aircraft, rather than traditional airfields.[43] Attritable systems, as the name implies, are designed to a lower price and level of capability and without human operators. This enables them to operate in riskier ways and accept more attrition than more expensive, manned platforms. Attritable systems therefore occupy a middle ground between standard systems—which are too costly in lives or money to be lost in large quantities—and expendable systems, which are designed to be thrown away.

Attritable aircraft could complement long-range aircraft by providing intelligence, surveillance, targeting, and communications. Other variants could provide limited air-to-air and air-to-ground/surface capabilities traditionally provided by manned fighters. Instead of operating forward early, manned fighters would operate from greater distances and manage the operations of unmanned systems farther forward. Then, as threats recede and attritable systems suffer losses, manned platforms could push forward into less contested environments.

The shift toward attritable aircraft is not a panacea for the logistical challenges of forward air operations, as they will have their own logistical hurdles. Attritable operations would require personnel and equipment for launch and recovery. These would require their own supporting infrastructure as well as host-nation basing access and support. Sustaining these operations would require fuel and munitions deliveries to numerous distributed ground sites.

These challenges are not trivial, but nor are they insurmountable. More importantly, distributed attritable aircraft operations would enable a more resilient—albeit less efficient—logistical system compared with manned fighters. Rather than large, fixed air bases with hangars and maintenance facilities, attritable aircraft could operate from open fields, parking lots, or stretches of roads. Targeting such distributed, movable sites would be harder than striking large, fixed facilities. Moreover, the consequences of successful enemy attacks would be contained, rather than systemic—destroying a fuel truck at an attritable launch site would not disrupt flight operations on the same scale as destroying the fuel pumps at a major air base, for example. Finally, attritable operations are temporary expedients to provide attrition-tolerant forward air power during the most contested period of a conflict. They are inherently unsustainable, since the aircraft will suffer attrition and these operations would eschew the maintenance needed to keep aircraft operating.

Another promising initiative is operating from a mix of smaller forward bases and arming and refueling points to generate persistent forward air power. This approach could improve the flexibility of U.S. tactical aviation and get it into the fight more quickly. But, like attritable operations, it has tradeoffs. Smaller airfields require

With the ability to take off and land with minimal runway support, unmanned aircraft such as the XQ-58 shown here could provide resilient forward combat air power during the opening weeks of a conflict with China or Russia. (Joshua King/U.S. Air Force)

host-nation access outside of existing bases. This can be hard to find in crowded locales like Japan. Distributed bases also place an enormous demand on ground crews, since each location requires a baseline personnel contingent for tasks such as security, regardless of the tempo of flight operations. To alleviate these pressures, experts consulted for this project suggested changing or making exceptions to Air Force policies to allow qualified allied personnel to perform some ground crew tasks. Small forward locations also could not conduct intensive maintenance, such as upkeep of stealth aircraft coatings. However, these tasks could take place at larger rearward bases. Last, providing air and missile defenses for these bases would be difficult; instead, they would have to rely on dispersal and evasion of adversary targeting for protection.

For maritime operations, sea bases—typically collections of large vessels such as tankers, aircraft carriers, or amphibious ships—can substitute for or supplement traditional land bases.[44] Sea basing and sea-base capabilities such as maritime pre-positioning ships or mobile expeditionary bases offer enormous geographic, political, and operational flexibility. Unfortunately, much like their landward counterparts, these large, high-signature floating bases offer tempting targets for Chinese or Russian attacks. Moreover, unlike land bases, sea bases cannot weather attacks and be quickly repaired. Despite these shortcomings, it may be possible to operate sea bases at acceptable levels of risk through a combination of greater distance from potential threats, emissions control and other countertargeting measures, defensive escorts, decoys and deception, and greater use of unmanned or minimally manned ships.[45]

Finally, ground-based long-range fires can strike critical targets early in a conflict, providing a more resilient adjunct to air-, sea-, and undersea-delivered strikes. Like attritable aircraft, these units require host-nation access, but smaller fixed infrastructure compared with an air base. However, unlike attritable aircraft, these land-based systems cannot self-deploy. Therefore, they would ideally be in place before a crisis; otherwise, they would need to be airlifted or sealifted into contested environments. Reactive deployments would not be impossible, but they would be risky and demand strategic lift assets that would already be under strain.

The foregoing initiatives sound daunting in total, but there are numerous pilot programs afoot.[46] Fully funding these initiatives will not be cheap, but the cost is relatively minor as a portion of the overall defense budget, and they would contribute substantially to creating a combat-credible posture at an acceptable cost. For reference's sake, the European Reassurance/Deterrence Initiatives cost almost $27 billion from FY 2015–2020, and Congress allocated $7.1 billion to the Pacific Deterrence Initiative in the FY 2022 National Defense Authorization Act, out of a total budget of $740 billion.[47] These sums are large but not staggering given their positive impact on U.S. operations.

Large, flexible platforms such as the USNS Montford Point Expeditionary Transfer Dock (foreground) and the USNS Bob Hope Sealift Ship (background), can support operations from survivable locations at sea. Despite this, the Pentagon's Fiscal Year 2023 budget request proposes decommissioning the Montford Point and its sister ship, the USNS John Glenn. (Shannon Renfroe/U.S. Navy)

Connectors

Adaptive logistics requires growth and diversification of the armed services' fleets of logistical connectors—the vehicles that connect the disparate parts of the logistics system. These investments will depend heavily on assumptions about posture and the demands of distributed operating concepts. Connectors that combine affordability, range, payload, and minimal dependence on large, fixed infrastructure could support a more distributed posture in contested environments. Adaptive logistics that can operate efficiently when conditions warrant but transition to resilient operations in contested environments require new connectors as complements, rather than replacements for existing fleets. Within this context, wargames and analysis suggest several potential investment areas.

In the maritime domain, the Marine Corps' Expeditionary Advanced Base Operations and the Navy's Distributed Maritime Operations concepts are driving interest in light amphibious warships and Next-Generation Logistics Ships based on commercial offshore support vessels. Wargaming and analysis suggest that these smaller vessels could contribute to a China conflict, but their usefulness depended heavily on access to Japan and the Philippines and some combination of Indonesia, Malaysia, or Vietnam. Expeditionary Advanced Base Operations, as the name implies, requires putting Marines ashore to establish advanced bases, which could support joint maneuver. Wargaming and analysis suggested this concept could establish more resilient and defensible lines of communication, provided the aforementioned basing access.

A larger number of smaller amphibious vessels and logistics ships is clearly a better match for distributed operating concepts. In a conflict, their small size would reduce the likelihood that an adversary would target them, and in the event of a successful strike, the loss of a single, relatively affordable ship would not be crippling. Naval analysts, such as Bryan Clark and Tim Walton, have suggested that light amphibious vessels and offshore vessel-based light oilers carrying approximately 30,000 barrels of fuel should be capable of supporting surface and shore operations over the long distances of the Pacific.[48] Rather than procuring new vessels, Marine Corps Captain Walker D. Mills and Navy Lieutenant Joseph Hanacek have suggested that the Marine Corps acquire some of the Army's amphibious watercraft, such as Frank S. Besson-class logistical support vessels.[49] This would fill a near-term gap and allow the Navy and Marine Corps to experiment before moving forward with designing and procuring new ships.

CNAS wargaming and modeling suggested, however, that light support ships were best suited to littoral operations in the Southeast Asian archipelago. Their limited payload made them less useful for open-ocean logistical support, especially for fuel resupply, since they would burn such a large portion of their limited fuel supply in transit. Moreover, ships with relatively limited range would be more reliant on politically sensitive and potentially unreliable access arrangements. These findings do not invalidate the idea of acquiring smaller, less expensive vessels to support distributed operations in the Indo-Pacific. But they suggest that this concept may work best as a complement to larger vessels, rather than as a substitute, and that further development of these concepts and capabilities requires close attention to assumptions about posture.

Supporting intermediate basing operations will require additional procurement of current systems, as well as investments in closing long-standing gaps in maritime logistics force structure. In their excellent "Sustaining the Fight: Resilient Maritime Logistics for a New Era," Timothy Walton, Harrison Schramm, and Ryan Boone describe components of a future sea-basing

Adaptive logistics that can operate efficiently when conditions warrant but transition to resilient operations in contested environments require new connectors as complements, rather than replacements for existing fleets.

capability: consolidated logistics ships (converted tankers capable of resupplying underway replenishment oilers or combat ships), dry cargo ships, and dedicated missile rearming ships for reloading vertical launch cells at sea.[50] Even if held outside the range of Chinese intermediate-range anti-ship ballistic missiles, a handful of such sea bases could increase surface-vessel time on station, reduce dependence on shore facilities at Guam, Yokosuka, and Pearl Harbor, and provide a needed hedge against the potential loss or degradation of other logistical hubs such as Singapore, whether through political constraints or enemy attacks. By increasing the time that surface and undersea combatants spend on station, these investments increase the effective size of the combat fleet more affordably than buying more warships.

The Joint Force and allies and partners have large fleets of C-130 cargo aircraft that can support distributed logistics concepts. In this photo, U.S. Marines practice airborne resupply with a KC-130J aerial refueling tanker on Ie Shima, a small island off the coast of Okinawa. (John Lamb/U.S. Marine Corps)

In the air domain, C-130 cargo aircraft and seaplanes both offer means to deliver munitions, spare parts, and other critical items to forward forces by landing on improvised runways or at sea, respectively. The large size of the C-130 fleet, their affordability, and their ability to operate from improvised runways could enable a resilient and flexible, point-to-point logistical network for distributed operations such as those envisioned in the Air Force's Agile Combat Employment concept.

Seaplanes, such as Japan's ShinMaywa US-2, offer even greater flexibility with regard to takeoff and landing sites. The late Art Corbett, a former Marine who heavily influenced distributed operating concepts such as Expeditionary Advanced Base Operations, was a staunch advocate of seaplanes.[51] In his vision, smaller, more flexible air, sea, and amphibious connectors could operate synergistically with dispersed operating locations and sea bases by quickly shuttling spare parts, munitions, and critical personnel between locations without need for a runway. As with offshore vessels, there are tradeoffs for this flexibility. These aircraft lack the range and payload of C-17 strategic airlifters. Their small size also limits the kinds of cargo they can carry—larger vehicles simply cannot fit in their cargo bays, for example. Nevertheless, these aircraft could effectively complement larger aircraft within an adaptive logistics concept.

On land, connectors such as heavy trucks appear to be less of a limiting factor than sealift or airlift. In European-theater wargames, for example, Russian red teams were reluctant to use their limited long-range strike arsenal against truck convoys, preferring instead to target bridges, railway marshaling yards, or other large, fixed infrastructure. Nevertheless, additional heavy trucks in Europe would certainly be an affordable way to increase the logistical and maneuver options available to future commanders.

Counterintuitively, additional trucks might be more useful to support distributed operations in the Indo-Pacific theater. Attritable aircraft, distributed basing, and ground-based long-range fires require an ability to deliver fuel, munitions, and personnel to austere sites in locations such as Japan, the Philippines, and Australia. This will require large fleets of trucks capable of operating on- and off-road, as well as an ability to maintain these trucks in the field. As the executive agent for logistics in the Indo-Pacific, this should be a critical Army mission and investment priority.

There is a final catch: Many of the systems described above do not exist or do not exist in sufficient numbers to support the distributed operations that the armed services believe are necessary to operate against China or Russia. Wargames and analysis dating back over a decade have identified vertical launch system rearming at sea as a critical capability for Pacific naval operations, for example, yet it inexplicably remains a gap in the Navy's force structure.[52] Seaplanes have a similar analytic pedigree. Despite their potential, the Air Force—specifically Air Force Special Operations Command—has only recently expressed real interest in developing a floatplane variant of the MC-130.[53] The Navy is developing capabilities to support dispersed sea bases, such as kits that turn commercial tankers into consolidated logistics ships described above, but the operative term is *developing*, rather than *procuring* at scale.[54] Other capabilities—for example, Expeditionary Transfer Docks and Expeditionary Sea Bases (sometimes known as Expeditionary Staging Bases)—exist in limited quantities and are oriented toward supporting operations in relatively permissive environments such as the Persian Gulf, rather than open ocean sea basing in the Indo-Pacific.[55]

Networks

The third area of focus in developing adaptive logistics is information management and networks. The Pentagon has invested large amounts of time and money to digitize the functions of the joint logistics enterprise over the last 30 years. While this has improved "visibility" into the enterprise, i.e., better knowledge about the status of logistical supply and demand, it has also allowed adversaries to penetrate these networks, exploit the information for intelligence purposes, or interfere with operations. There are two information imperatives pulling the enterprise in seemingly opposing directions. The first is the desire to further improve visibility across the enterprise by removing barriers between information systems to create enterprise-level solutions and shared data. The second is to increase the security of this information and prevent adversaries from being able to exploit, disrupt, or degrade these systems.[56]

Wargaming and examinations of Chinese and Russian doctrine suggest that the probing attacks regularly experienced by U.S. logistics networks will escalate during a crisis, providing China or Russia with intelligence about the disposition and readiness of U.S. forces, as well as an ability to delay or disrupt U.S. responses. Moreover, the sheer scope of the joint logistics enterprise—as well as the diversity of its users, including foreign entities—prevents preclusive network defense. Even if the Pentagon works to improve the trustworthiness and cybersecurity practices of its contractors, the number of users and potential vulnerabilities across the system is staggering.

Developing information and control networks that simultaneously provide visibility and security will require a layered, multifaceted approach blending new technologies, new organizational constructs, and increased training, along with deception and countermeasures to adversary exploitation.

Developing information and control networks that simultaneously provide visibility and security will require a layered, multifaceted approach blending new technologies, new organizational constructs, and increased training, along with deception and countermeasures to adversary exploitation. In their paper on survivable logistics, the Defense Science Board identified blockchain technologies as one means of maintaining security in a relatively open system.[57] Artificially intelligent network and data-security systems could also enhance security by flagging anomalous activity and data for further interrogation by cybersecurity teams. The Defense Chief Information Office has suggested adopting "zero-trust" information architectures in which "no actor, system, network, or service operating outside or within the security perimeter is trusted."[58] Such systems would be ideal for the joint logistics enterprise, since these networks must connect users with differing levels of security.

Organizationally, unclassified logistics networks should remain federated to prevent security failures from spreading and creating enterprise-wide disruptions. Federating information networks—i.e., organizing them into subsystems that can function independently when needed or as part of a broader whole when possible—is key to enabling forward forces to sustain operations in highly contested environments, both in physical and digital domains. U.S. forces operating from Japan or the Baltic region must have logistical information systems and computer networks that do not require constant connection to external networks or data sources. China and Russia will attack these networks early in a conflict, or perhaps even before a conflict, to disrupt and slow a potential U.S. response. Larger networks, such as the F-35's Operational Data Integrated Network, the Global Combat Support System-Joint, and even the Defense Finance and Accounting Service, must be able to devolve into localized subnetworks that allow for continuity of forward operations absent reliable external connectivity. While it is tempting to consolidate networks for efficiency, the joint logistics enterprise needs to avoid presenting massive network "attack surfaces" that can disrupt operations globally.

Centralized systems that share data across the enterprise, or any system managing critical missions such as aerial refueling, should remain on secure, classified networks with limited and closely monitored access. Logistics personnel should train to identify aberrant activity on their systems and conduct exercises in which they execute their combat missions with disrupted, degraded, and penetrated networks. Logistics networks should incorporate cyber "honey pots" to attract and identify intruders, as these are systems that are highly likely to be attacked. Lastly, U.S. offensive cyber capabilities should prioritize preemptive operations against adversary cyber actors known to target logistics systems.

Given the size and character of logistics information networks, there likely is no way to ensure enterprise-wide visibility *and* security of logistical information. The foregoing steps would improve matters, but the most important lesson is that U.S. logisticians, and the commanders who depend on their support, must prepare for the inevitability of disrupted and degraded logistics information. This further reinforces the use of "push" logistics inside an adaptive logistics concept—as information networks degrade, logisticians must be ready to push critical supplies and materiel forward, rather than wait for resupply requests via degraded networks.

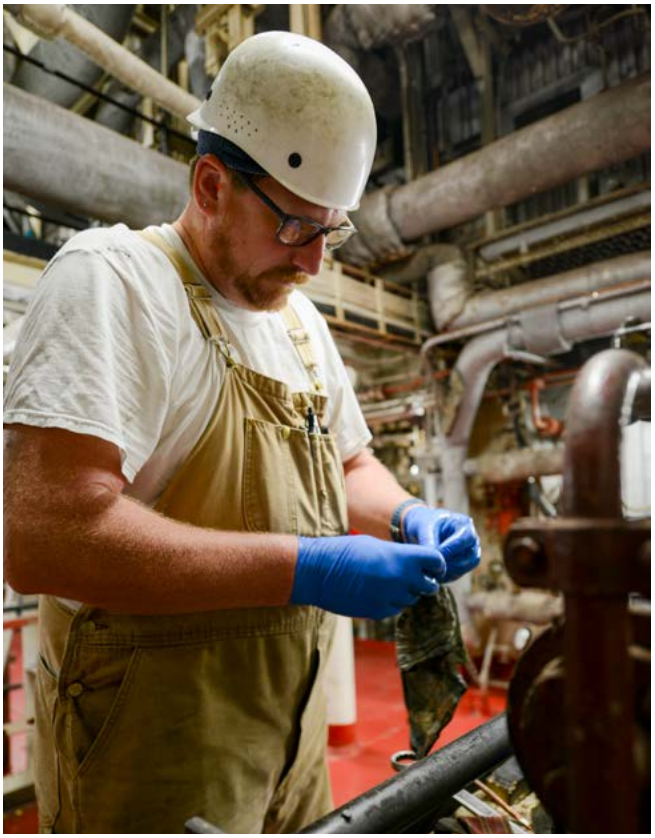
Personnel

Logistics depends on people.[59] During a wargame, a Chinese red team drove this point home when it attacked the housing facility for Air Force maintainers in Japan. Why try to kill pilots and destroy aircraft in the air, they reasoned, when a salvo of missiles against undefended barracks and housing facilities could kill, wound, or disable the ground crews that got U.S. aircraft ready to fly?

This move highlighted the fact that the limiting factor for dispersed air operations is qualified ground crews to "turn"—i.e., refuel and rearm—aircraft. The Air Force is trying to alleviate this constraint by developing "multi-capable airmen."[60] This initiative aims to turn specialized ground crew personnel such as F-16 maintainers into flexible airmen who can defend an air base, unload a cargo aircraft, or load munitions on multiple aircraft types.[61] This is a useful effort, but each airman can only execute one task at a time and specific training and expertise matter for these technically demanding jobs. Moreover, giving multiple responsibilities to a small ground crew can increase the consequences of attrition, since losing one person would impact multiple critical tasks.

Allied and partner personnel offer a potential source of additional manpower, particularly in countries whose armed forces operate U.S. weapons systems. Concerns about protecting sensitive, classified systems may prevent these personnel from performing some tasks (although these policies should be revisited to create exceptions during war), but they could carry out others, such as security, thereby freeing up U.S. personnel. Pooling logistics manpower in this way could also prove useful in other areas, such as port opening; movement control; and reception, staging, and onward integration.

The Navy also faces personnel limitations in its logistical forces. The Military Sealift Command, and its wide range of support vessels including the Combat Logistics Force, relies on civilian and contract merchant mariners to staff its ships. The contract mariners—qualified civilians serving on U.S.-flagged ships—are critical to mobilizing the nation's reserve of sealift capacity in an emergency. Given concerns about this workforce, Congress mandated the Maritime Administration to conduct a survey to determine its size and sufficiency to meet national security demands.[62] The report contained several worrying findings. First, the Maritime



The vast joint logistics enterprise rests on critical personnel like merchant mariners, who are among the few mariners able to maintain the aging steam plants that power the fast sealift ships of the U.S. Maritime Administration's Ready Reserve Fleet. (Billy Ho/U.S. Navy)

Administration had no firm head count of the number of qualified mariners. Second, based on surveys and estimates, the number of mariners was insufficient to fully staff the nation's surge sealift fleet in an emergency, even if every qualified mariner volunteered. Third, the number of qualified mariners was declining and, based on the reduction in U.S.-flagged open ocean ships, would continue to drop. Fourth, the mariners accessioning into the merchant marine today frequently lack the qualifications or experience needed to operate the aging steam plants that power much of the reserve sealift fleet. This report and other surveys paint a picture of old and

unreliable sealift fleet manned by a small and shrinking workforce, neither of which appear to be up to the challenge posed by conflict with China or Russia.[63] The Navy and the Maritime Administration need to collaborate to close these personnel shortfalls and identify ways to address the long-term decline of the U.S. merchant marine.

Movement Control Teams and Rapid Port Opening Elements are the Army's example of relatively limited numbers of personnel upon which major logistical efforts and operations rely. As their names imply, Movement Control Teams manage the movement of forces and materiel, while Rapid Port Opening Elements ensure that seaports are ready to receive and process forces and materiel.[64] Wargaming and operational analysis have long suggested that capacity in these critical support elements is insufficient to support major conflict operations and that these shortfalls would be more acute in a conflict with China or Russia, since they might target these critical personnel. There are two steps the Army can take to address these issues. First, it can increase the number of Movement Control Teams and Rapid Port Opening Elements. Second, it can transition some of its existing units from the reserve component to active duty, to ensure their availability during a crisis.

Contractor workforces are a limiting factor across the joint logistics enterprise. Outsourcing of logistical tasks, combined with an increased focus among contractors on lucrative, long-term service contracts, has created situations across the Joint Force wherein critical logistical functions depend on a small number of contractors. Experts consulted for this paper cited numerous instances in which a lone contractor was the only person authorized to work on a given system—a literal single point of failure. These experts also expressed frustration with instances wherein only contractors were contractually able to repair a critical system, but those contractors were not always available. The strain of combat would magnify these concerns. Experts believed that some contractors would continue to provide support, regardless of risk, but that others would not, potentially creating major gaps in logistics and sustainment. These discussions are classic anecdata—personal stories, rather than products of detailed analysis. Nevertheless, the volume and similarity of the stories from across different services and sectors of the logistics enterprise speak to their legitimacy. The Defense Department and broader defense community need to systematically assess and take steps to mitigate the potential combat risks created by contractors in the logistics enterprise.

Investing in unmanned systems is often touted as a way to reduce personnel and associated logistical burdens.

If the armed services realize their future visions of dispersed operations using fleets comprising manned and unmanned systems, including large swarms of affordable drones, the demand for technically proficient logisticians and maintainers will likely increase.

While unmanned systems reduce some logistics burdens (e.g., housing, feeding, and providing health care for vehicle operators), they do not eliminate the need for logisticians. Personnel are still required to fuel, arm, maintain, repair, transport, and dispose of unmanned systems. If the armed services realize their future visions of dispersed operations using fleets comprising manned and unmanned systems, including large swarms of affordable drones, the demand for technically proficient logisticians and maintainers will likely increase in both absolute terms and as a relative percentage of the overall force. The solution, as is often the case with logistics shortfalls, is not overly complex, but rather unpopular: The Pentagon should increase the size and technical sophistication of its military and civilian logistical workforce, with a focus on occupational specialties, such as aircraft maintainers, that directly impact the operational options available to commanders.

The work of this naval logistics specialist for submarines captures the fragile human foundation of the joint logistics enterprise. He was solely responsible for shipping critical parts to submarines throughout the Indo-Pacific. (Nicholas Pilch/U.S. Air Force)

Laying the Foundation for Change

Building an adaptive logistics concept is a massive but necessary undertaking. It will require investment and change in nearly every aspect of defense operations. Change on this scale requires a strong foundation. Unfortunately, the present foundation for change is weak. Budgets for logistics are insufficient. Pentagon processes do not adequately account for logistical demands. And the culture of the armed forces and defense community tends to marginalize logistics and logisticians. The following section outlines changes in budget, processes, and culture necessary to implement an adaptive logistics concept.

Increasing Investments in Logistics

Developing an adaptive logistics concept and investing in force posture, more secure networks, diverse new connectors, and a larger, better-trained workforce will not be cheap. It requires substantial and sustained investment. A detailed budget analysis is outside the scope of this project, but analysis suggests that investments in logistics—including posture improvements, increased munitions stockpiles, and at-sea rearming of Navy ships' vertical launch cells—would increase effective combat power in a potential conflict at far lower cost than adding more combat forces. In their paper on maritime logistics, Walton, Schramm, and Boone reached a similar conclusion regarding the Navy's budget—giving a larger percentage of the budget to logistics is a more cost-effective way of increasing combat power.[65] Generally speaking, logistical assets are less expensive than combat assets and, since their contributions to combat effectiveness are multiplicative rather than additive, investments in logistics yield disproportional benefits.

Shifting money away from combat forces to logistical accounts is a bold move. It would be especially brave in an era when the defense commentariat is obsessed with "lethality" and simplistically equates it with combat forces. Despite this viewpoint, it is a sound decision and one that could have significant ramifications for the U.S. industrial base and prove popular with both sides of a divided Congress. Unlike combat forces, many logistical platforms and systems are closely related to commercial systems. Air Force refueling tankers are based on commercial aircraft. Combat Logistics Force and Maritime Sealift Command ships are often minimally modified civilian vessels. A commitment to recapitalizing sealift fleets with U.S.-built commercial-based vessels, for instance, could provide much-needed investment and market demand to regrow the withered U.S. commercial shipbuilding base. This sort of public-private partnership has a long history in the United States, and China is using a similar model to bolster its amphibious lift capacity using civilian shipping.[66]

In shifting resources toward logistics, it is crucial that the Pentagon focus on developing a sufficient set of options, rather than optimizing efficiency for particular

While supposedly ready to deploy in either five or ten days, much of the Maritime Administration's Ready Reserve Fleet is aging and difficult to repair. Since most of these ships are based on commercial designs, recapitalizing this fleet could simultaneously reinvigorate U.S. sealift and commercial shipbuilding. (Billy Ho/U.S. Navy)

plans or operational concepts. As Thomas Kane put it, "Logistics helps determine which side will have the most options available, not what those options will be or how effectively it will use them."[67] Adversaries, fog, and friction will disrupt plans and thwart optimization. Focusing on developing multiple credible logistics options will allow commanders to sustain operational tempo under attack and maintain operational flexibility.[68]

Changing Processes to Emphasize Logistics

Building adaptive logistics will require changes to how Pentagon processes—including planning, programming, budgeting, and execution—treat logistics. There are many ways in which these processes marginalize rather than emphasize logistics. The department's now-defunct joint analysis process, "Support for Strategic Analysis," and the "Analytic Agenda" that preceded it are good examples. These processes built the scenarios and concepts of operations used to develop service programs and analyze and assess the ability of the Joint Force to execute the defense strategy. These products were quite elaborate and could take 12–18 months to complete. However, only *after* completion would logistical analysts determine if the concept of operations was logistically feasible. In one of the most important products informing the Pentagon's force-planning decisions, logistics was, literally, an afterthought.

There are other ways in which Pentagon processes systematically marginalize logistics. Logistical analyses, such as the Mobility Capabilities Requirements Study, usually use present-day operational plans as a starting point to determine the quantity of logistical assets the Joint Force needs to execute its strategy. There is, however, a problem with this approach. Operational plans are developed by the combatant commands for immediate execution. They are therefore "resource-informed," meaning they are built using the current inventory of the Joint Force. This creates an analytical tautology. The quantity of logistical assets required equals the quantity of logistical assets in the plans, which equals the quantity of logistical assets in the Joint Force. By definition, therefore, the Joint Force has sufficient logistical assets in perpetuity, regardless of what future demand might actually be.

Logistical assets are generally less expensive than combat assets and, since their contributions to combat effectiveness are multiplicative rather than additive, investments in logistics yield disproportional benefits.

Wargaming and analysis often eschew detailed examinations of logistics at the campaign level.[69] This is not to say logistical analysis does not exist, but this work tends to be siloed within logistical organizations like the Joint Staff J-4, rather than clearly incorporated into major force-planning efforts and debated in key forums with senior leaders. Wargaming can be particularly egregious in its treatment of logistics. Wargames pitting U.S. forces against China or Russia almost universally identify logistics as a critical U.S. vulnerability and an area for exploration. Yet wargame designers often remove or "abstract" logistics for the sake of simplicity or playability. Wargames that focus on logistics, rather than treat it as a background topic in a combat-focused game, remain rare.

In addition to marginalizing logistics, processes can shape thinking about logistics in harmful ways by emphasizing cost-efficiency above more relevant metrics such as combat effectiveness. Investing in combat sufficiency instead of peacetime efficiency requires a different mindset and metrics of performance than those often used in logistical analyses. Metrics for a "lean" logistics enterprise prize small stockpiles of materiel and high "velocity" of inventory—i.e., how quickly an item moves through the enterprise to a consumer—in this case an operational unit. This approach helps keep costs down, but it requires detailed information and predictable supply and demand. If one aspect goes askew—for example, an adversary cyberattack disrupts the flow of information—it can quickly fall apart. A metric focused on combat sufficiency might instead focus on supporting a given quantity of forces operating at high tempo under realistic combat conditions, including disruptions to information and command systems, and then size, shape, and position its stockpiles of materiel accordingly. This change in foundational assumptions from efficiency to sufficiency results in fundamentally different objective metrics and radically different investments.

These are just some examples of the ways in which key Pentagon processes fail to capture the importance of logistics or emphasize the wrong objectives; there are certainly more. The solution, as it has been throughout this paper, is simple but seemingly difficult: Logistics and logisticians need a seat at the table. Rather than spending years developing plans and concepts, then asking logisticians to assess their viability after the fact, logistics must be central to the planning and concept development process from start to finish. Wargaming should incorporate logistics in

ways that present players with realistic constraints and dilemmas. The wargaming and analytic community needs to spend more time and resources examining logistics in the context of combat operations with China or Russia. Most importantly, senior Pentagon leaders and members of Congress must demand this kind of work and hold it to the same level of scrutiny as they do analysis of combat capabilities.

Changing Cultural Perceptions of Logistics

The fact that logistics remains a source of savings in budget discussions and an afterthought in planning and analysis speaks to a deeper issue with how military personnel and organizations perceive and treat logistics and logisticians. The infamous Alexander the Great quote, "My logisticians are a humorless lot. They know they are the first ones I will slay if my campaign fails," is almost certainly apocryphal. And yet it is an apt description of the bizarre relationship between combat forces and logisticians. Most combat personnel understand how much they depend on logisticians but in practice treat them like second-class citizens, or worse. Pejorative phrases like "in the rear with the gear," "pogues," and "Fobbits" (a portmanteau of the acronym for a forward operating base and a hobbit) speak to this attitude. Tellingly, from the Civil War through the Korean War and the eventual desegregation of the Army, segregated African American units were often relegated to logistical missions, such as the famous Red Ball Express transport units of World War II.[70]

This cultural disparagement of logistics has serious, tangible impacts on the armed forces. Though direct causality is difficult to prove, it likely contributes to the lack of time, energy, and money spent on logistics. Indirectly, it contributes to service and bureaucratic cultures that push the most talented personnel toward combat career fields, then promote those personnel to the highest levels of the armed services. Air Force Generals Norton Schwartz and Paul Selva, the former chief of staff of the Air Force and former vice chairman of the Joint Chiefs of Staff respectively, stand out as some of the few generals with logistical backgrounds who have reached top positions in the Pentagon. Both commanded United States Transportation Command, one of the few four-star commands given to officers with logistical backgrounds.

Prestige and promotions attract talent, and more talent is needed if the Pentagon is going to develop an adaptive logistics concept capable of supporting combat operations against China or Russia. The Pentagon and the armed services need to make logistics a prestigious part of the Joint Force, rather than a second-rate assignment. The Defense Department, the armed services, and Congress should work together to institute reforms in talent management across enlisted, officer, and civilian workforces to ensure that talented individuals enter the logistical enterprise, remain in it, and advance their careers at rates equal to their peers in combat forces.

Beyond targeted reforms of personnel policies, the Pentagon and the broader defense community should

The relegation of African American soldiers to logistical operations in the era before desegregation of the armed forces speaks to persistent negative cultural attitudes toward logistics. Despite this treatment, soldiers of the Red Ball Express, pictured here, were vital to supporting the Allied push across Europe in World War II. (U.S. Army)

Every link in every kill chain depends on logistics. Here, a Marine logistician refuels a Navy P-8 Poseidon maritime patrol aircraft as part of the Talisman Sabre 21 exercise in Australia. (Bryant Rodriguez/U.S. Marine Corps)

conceptualize logistics as critical components of so-called kill chains. This term, first used to describe the concatenation of systems and actions necessary to execute a precision strike, has become popularized and broadened within the military vernacular, particularly with the release of Christian Brose's book *The Kill Chain*.[71] A kill chain requires every "link" to function properly so, somewhat tautologically, every system within the chain is mission-critical. Kill-chain analyses, particularly against high-priority target sets, therefore hold a great deal of sway in programming and budget discussions. Programs that occupy key positions in high-priority kill chains are well protected when the Pentagon builds its budgets. If those programs lack viable alternatives, their budget can become virtually sacrosanct. Alternatively, programs outside of these priority investment areas—for example, logistics—become budgetary "trade space" that can be reallocated.

The argument for considering logistics as integral to kill chains has the benefit of being true. A common definition of a kill chain for a moving target is "find, fix, track, target, engage, and assess." In this process, the wide-area surveillance aircraft that finds a target and fixes its location must take off from a forward base, where it receives maintenance and fuel, then uses aerial refueling to stay on station. The aircraft that then tracks the target and provides more detailed targeting data also requires a base and aerial refueling. The strike aircraft that engages the target must be loaded with munitions (which arrive at the base on transports) and fuel at a forward base, then refuel from aerial tankers on its way to the target and on its way back to base. Finally, the intelligence aircraft that assesses the outcome of the strike also requires a forward base and, in all likelihood, aerial refueling. Finally, the air operations center that plans and commands the strike needs all manner of logistical support. Every aircraft, ship, vehicle, service member, and facility that makes up a kill chain relies on logistical support at every link in the chain. Yet critical supporting functions such as "load, maintain, and fuel" never appear in representations of kill chains.

In theory, the Pentagon should also move beyond the arbitrary categorization of programs into mission-critical combat systems and noncritical support systems, as it has distorted force planning and created the current unbalanced force. However, since the Pentagon is unlikely to upend the way it develops programs, budgets, and forces, building a narrative around logistics as a critical part of kill chains may be a more feasible approach to increasing its prioritization in the budget.

A stronger cultural appreciation for logistics will not create a more effective joint logistics enterprise. It will not improve sustainment of forces operating inside contested environments, nor will it increase the responsiveness and resilience of U.S. strategic mobility. It can, however, create a more conducive environment for such initiatives. Without a greater department-wide appreciation for the importance of logistics, the sustained senior-leader attention and budget allocations necessary to bring these initiatives to fruition will not be possible.

Prestige and promotions attract talent, and more talent is needed if the Pentagon is going to develop an adaptive logistics concept capable of supporting combat operations against China or Russia.

Conclusion

Despite its frequent second-class status, logistics has played a starring role in American military history. From the Army's deft use of railroads and rivers to defeat the Confederacy to the Air Force's evacuation of thousands of Americans and Afghan refugees to safety after the fall of Kabul to the Taliban, logistics has been a core U.S. strength for over 150 years. U.S. logisticians make difficult tasks seem easy and find ways to make the impossible happen. Too often, however, U.S. armed forces take wartime logistical successes for granted, forget the lessons of past conflicts, and focus instead on combat operations. This tendency has historically forced the Department of Defense and the armed services to relearn difficult lessons about providing logistical support under fire. War with China or Russia, occurring as it will under the overhang of strategic escalation including nuclear weapons, may not provide U.S. forces with the time and space to learn from early mistakes. Logistical failures early in a future conflict may result in strategic concessions at war's end. This tight margin for error in the event of war makes it imperative for the Pentagon to start developing an adaptive concept for joint logistics now, instead of waiting to adapt in combat.

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7. Dougherty, "Why America Needs a New Way of War," 33-34.

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