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Cratering Effects

Chinese Missile Threats to US Air Bases in the Indo-Pacific

By Kelly A. Grieco, Hunter Slingbaum, and Jonathan M. Walker

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Cratering Effects

Chinese Missile Threats to US Air Bases in the Indo-Pacific

Chinese missiles attacks on air bases could thwart effective U.S. sortie generation at the outset of a military conflict.

By Kelly A. Grieco, Hunter Slingbaum, and Jonathan M. Walker

The U.S. Air Force—with its ability to respond where and when needed to aggression by adversaries—has long underwritten U.S. extended deterrence commitments. Today, however, that capability is at risk. For the last three decades, China has built a large and modern missile arsenal capable of attacking the runways needed for the effective projection of American airpower in the region. This report finds that Chinese missiles attacks could close the runways and taxiways at U.S. forward air bases in Japan, Guam, and other Pacific locations in the first critical days—and even weeks—of a war between the United States and China. No combination of U.S. countermeasures—including the greater dispersal of aircraft in the region, improved runway repair capabilities, and more robust missile defenses—is likely to solve the problem. There is a real and growing danger that Beijing might conclude that it could keep American airpower at bay long enough to accomplish a quick fait accompli. To strengthen deterrence, the U.S. Air Force should build a credible "inside air force," prioritizing large numbers of lower-cost, mobile, and runway-independent platforms that can support allied- and partner-led air denial operations within the First Island Chain.

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Photo by Staff Sgt. Christopher Tam

Executive Summary

During the last thirty years—dating back to the 1991 Gulf War—U.S. overseas air bases were largely safe havens from enemy attacks. These sanctuaries enabled the rapid projection of American airpower to deter adversaries and reassure allies and partners in times of crisis. That sanctuary age has now ended, and nowhere more than in the Indo-Pacific.

China has invested heavily in building a large and sophisticated arsenal of ground-launched ballistic and cruise missiles that can reach U.S. bases across the region. In the view of Chinese military strategists, the weak points of American airpower projection are the forward air bases—especially the runways—which are vulnerable to missile attacks. Unfortunately, Chinese strategists are correct. By denying the United States the use of runways and taxiways in the region, the People's Liberation Army (PLA) could gain air superiority without ever defeating America's arsenal of advanced fighters and bombers.

This sobering reality has drawn congressional attention. In May 2024, for example, 13 members of Congress sent a letter to the secretaries of the Air Force and Navy, warning that Chinese missile threats "significantly weaken our ability to respond in a conflict" and calling on the Pentagon to urgently build hardened aircraft shelters, underground bunkers, and other facilities to improve the resilience of U.S. bases in the Indo-Pacific.[1] These ideas may have merit, but even with hardening, U.S. air bases still have an Achilles' heel—the runways themselves.

Accordingly, this report models repeated Chinese missile attacks on U.S. military runways and taxiways in Japan, Northern Marianas, and other Pacific islands, employing conservative assumptions and relying on open-source data to estimate the PLA Rocket Force's (PLARF's) order- of-battle and missile capabilities as well as U.S. basing access, runway repair times, and missile defense capabilities. It finds that Chinese missiles attacks could indeed close these runways and taxiways in the critical first days—and even weeks—of a war between the United States and China.

These attacks could prevent the U.S. Air Force from conducting fighter operations for about the first 12 days of a conflict from U.S. air bases in Japan and nearly two days from U.S. bases in Guam and other Pacific locations at the outset of war. In practice, however, China could disrupt U.S. combat operations for much longer by denying the United States the use of runways to conduct aerial refueling operations. This study shows that Chinese missiles could close runways to aerial refueling tankers and other large aircraft for over a month at U.S. bases in Japan and over half a week at U.S. military bases in the region.

Without aerial refueling from tankers, many U.S. aircraft—including fifth-generation fighter jets—lack the internal fuel capacity to close the distance to targets in the Taiwan Strait or South China Sea and return to existing U.S. bases in the region. These runway closures could also push back U.S. bombers to bases in Australia, Hawaii, or Alaska at the outset of a conflict, adding hours to the flight times and substantially reducing the number of bomber sorties that the United States could generate each day.

Addressing this threat to U.S. air bases is arguably the most critical and daunting task facing the U.S. Air Force today. The Air Force finds itself in danger of operating much less effectively than previously assessed, if at all, at the start of a military conflict when the Joint Force would expect it to quickly set up a combat air patrol or sink Chinese ships in the Taiwan Strait. Worse, Chinese military planners might calculate that they have a window of over 30 days—when American airpower would be largely sidelined—to accomplish a fait accompli. If Beijing concludes that it can win a quick and easy military victory, its actions could become very hard to deter.

Unfortunately, there are no easy ways to counter the threat from Chinese missile strikes on U.S. air bases in Japan, Guam, and other Pacific Island locations. Even if the United States employed a mix of countermeasures—dispersing aircraft and personnel to reserve bases and civilian airfields, improving rapid runway repair capabilities, and building a more robust missile defense architecture in the region—runways in Japan, Guam, and elsewhere would remain closed to tanker operations for at least the first several days of any conflict.

To restore its ability to project airpower early in a war, the United States will need to outthink—not outspend—the PLA. Instead of doubling down on old paradigms, the Air Force ought to embrace new operational concepts and capabilities for employing airpower at the start of a conflict, as follows:

- The United States should leverage this age of precision weapons en masse to strategic and operational advantage, shifting the bulk of the burden for contesting control of the air early in a war to its allies and partners.
- U.S. allies and partners should implement strategies of air denial and build their air forces around large numbers of drones and missiles of all types to ensure that they can keep the skies contested and blunt Chinese attacks early in a war without massive support from American fighters and bombers.
- The U.S. Air Force should support allied- and partner-led air denial operations within the First Island Chain.[2] This inside air force—forward-postured air units tasked, trained, and equipped to operate in contested airspace—should be built around large numbers of attritable[3], mobile, and runway-independent platforms rather than traditional fighters and bombers. U.S. bombers, as well as cargo aircraft armed with palletized munitions, should play a secondary role in blunting Chinese attacks, but they should not be a substitute for an active inside air force.
- The U.S. Air Force should prioritize logistics and sustainment to ensure this inside air force remains in the fight. Doing so requires more investment in prepositioned stockpiles and infrastructure improvements, including upgrades to civilian airfields in the Pacific; hardened fuel-storage facilities; and dispersed storage facilities containing weapons, munitions, and equipment, including runway repair kits.

Above all, American political and military leaders—as well as the American public—should be under no illusions: there will be no refuge or rest from the long reach of Chinese missiles for U.S. air bases in a war. U.S. decision-makers should ask themselves the hard questions: whether—and when—paying that high price in materiel and human lives will be in the United States' national interest.

Introduction

The U.S. Air Force has a proud motto: "To fly, fight, and win—airpower anytime, anywhere."[4] The service is often the first to respond in a crisis or conflict—from the B-1 and B-52 bombers that conducted some of the first strikes against the Taliban and Al Qaeda in Afghanistan in the wake of 9/11 to the fighter jets that deployed to Eastern Europe in the days after Russia invaded Ukraine in 2022 to reassure NATO allies and bolster deterrence.[5]

The ability of the Air Force to deliver massive firepower when and where needed has long underwritten U.S. extended deterrence. For some 30 years, forward-deployed U.S. warplanes were ready to blunt adversary attacks, helping to shore up allied and partner defenses and buy time for U.S. reinforcements to arrive in the theater. American airpower promised to respond quickly and decisively to military aggression, thus denying any revisionist actor the opportunity to achieve a quick and easy military victory.

Needless to say, U.S. adversaries took notice. In the thirty years since the First Gulf War, China has modernized the People's Liberation Army (PLA), building advanced anti-access/area-denial (A2/AD) capabilities to keep U.S. warplanes at bay should China fight a war over Taiwan or the South China Sea.[6] In the view of Chinese military strategists, the weak points in America's ability to project airpower in the Indo-Pacific are the forward air bases—especially the runways—which are vulnerable to missile attacks. The Chinese "have noticed it's quite obvious that we depend upon a small number of assets, including forward air bases, to conduct operations," Secretary of the Air Force Frank Kendall has warned, noting, "Because they're fixed, they're easily targetable, and they've built the assets to come after them."[7]

And the problem is only getting worse. The PLA Rocket Force (PLARF) now fields significantly more medium- and intermediate-range ballistic missiles than it did a decade ago, as well as ground-launched cruise missiles capable of striking targets upwards of thousands of miles away, bringing all of Japan's territory, as well as Guam, within its coverage.[8] Today, Chinese missiles are not only more accurate and capable than previous ones, but this large and diverse arsenal threatens the prospect of coordinated multi-axis strikes involving ballistic and cruise missiles, which would complicate the United States' task of missile defense.

> ***Runways are required to launch and recover not only fighters and bombers but also the aerial refueling tankers and other support aircraft required to keep them in the fight.***

If PLARF missiles damage these runways such that U.S. aircraft can neither take off nor land, they will threaten to bring U.S. forward air operations to a screeching halt. The runways are required to launch and recover not only fighters and bombers but also the aerial refueling tankers and other support aircraft required to keep them in the fight. Many U.S. aircraft, including fifth-generation U.S. fighter jets, lack the internal fuel capacity to close the distance to targets in the Taiwan Strait, for example, and return to existing U.S. bases in the region, including most in Japan.

This report assesses evolving Chinese missile threats to U.S. air bases in the region and evaluates the effectiveness of various mitigation measures, including missile defense, reduced runway repair times, and the dispersion of U.S. aircraft and personnel to more operating locations across the theater. The research team developed a statistical modeling script in Python to calculate the number of hours that Chinese missiles could deny the use of U.S. air bases and Japan Air Self Defense Force (JASDF) bases, as well as civilian runways in Japan, Guam, the Northern Mariana Islands, and the Pacific Freely Associated States. [9] The model employs conservative assumptions and relies on open-source data to estimate the PLARF's order-of-battle and missile capabilities as well U.S. military access, runway repair times, and missile defense capabilities.[10] The analysis is illustrative and cannot predict with absolute certainty how PLARF ballistic and cruise missile attacks on runways would play out in a real war, given that real-world outcomes depend on a range of other nonmaterial factors, such as civil-military relations, logistical support, and military readiness and skill levels.[11] Instead, it provides a closer look at the problem set and offers proposed solutions to inform policymakers and advance the public debate.

The study makes three contributions to the literature, building on previous work, including RAND's 2015 study, the U.S.-China Military Scorecard, which examined a notional attack on Kadena Air Base in Okinawa, Japan, and the Center for New American Security's 2017 analysis, "First Strike: China's Missile Threat to U.S. Bases in Asia," analyzing attacks on existing U.S. bases in Japan.[12] First, it accounts for China's growing ability to hold runways in the Second Island Chain at risk, modeling attacks on runways located not only in Japan but also those in Guam, the Northern Mariana Islands, and the Pacific Freely Associated States. Second, it models what is arguably the most likely scenario—the United States has military access to runways in Guam, the Northern Mariana Islands, and the Pacific Freely Associated States, but the only other country in the region to grant contingency access is close ally Japan. Finally, the study evaluates the effectiveness of various mitigation measures, including missile defense, reduced runway repair times, and the dispersion of U.S. aircraft and personnel to more operating locations across the theater, including Japanese Self-Defense Force bases as well as civilian airfields, assuming the United States had the required political permissions and the necessary prepositioned equipment, lighting, and repair crews.

The study finds that PLARF missile attacks could close the runways and taxiways at U.S. forward air bases in the critical first days—and even weeks—of a war between the United States and China. These attacks would prevent the U.S. Air Force from conducting fighter operations for about the first 12 days of a conflict from U.S. air bases in Japan. China's growing reach now also threatens to keep U.S. air bases in Guam and other Pacific locations closed to fighters for about two days at the outset of a war. In practice, however, the PLARF could disrupt U.S. combat operations for much longer by denying the use of aerial refueling tankers required to cover the distances to targets.

Most important, Chinese missiles can close runways to U.S. tankers for over a month at U.S. bases in Japan and a minimum of four days at U.S. military runways in Guam, the Northern Mariana Islands, and the Pacific Freely Associated States. Without aerial refueling from tankers, U.S. fighters will not be able to put most of their weapons within range—much less fly a combat air patrol over Taiwan or the South China Sea.[13] These same runway closures threaten to degrade U.S. long-range strike operations, pushing back the American bombers expected to sink Chinese warships in any defense of Taiwan.[14] The U.S. Air Force could launch aircraft from bases even farther away—in Australia, Hawaii, or Alaska—but operating over such long distances would add hours to the flight times and substantially reduce the number of combat and support sorties flown per day, making it difficult to wield American airpower decisively.[15]

The implications for deterrence are worrisome: Given that achieving air superiority is critical to the PLA's strategy to achieve victory, especially in a Taiwan scenario, there is a real and growing danger that Beijing might conclude that its missiles could keep U.S. forward-deployed aircraft at bay long enough for the PLA to achieve a quick and decisive military victory.[16] Chinese military planners could calculate that they have a window of upwards of 30 days—when PLARF missiles would close runways to U.S. tanker aircraft—to achieve the air superiority required to seize Taiwan, without the need to defeat U.S. air superiority fighters in combat. PLA leaders have many other reasons to doubt China's prospects for accomplishing a fait accompli—invading Taiwan, with its narrow beaches and rugged terrain, would remain a daunting gamble—but there is a risk they will convince themselves that they can win—and win quickly—without the interference of American airpower.[17]

> ***The U.S. Air Force finds itself in danger of operating much less effectively, if at all, at the beginning of a conflict when the Joint Force would expect it to quickly set up a combat air patrol or sink Chinese ships in the Taiwan Strait.***

Unfortunately, there are no easy solutions to mitigate the threat. This analysis shows that even if the United States employed a mix of countermeasures—dispersing aircraft and personnel to reserve bases and civilian airfields, improving rapid runway repair capabilities, and building a more robust missile defense architecture in the region—runways in Japan, Guam, and elsewhere would remain closed to tanker operations for at least the first several days of any conflict.

The United States cannot buy its way out of the problem with a set of costly investments in air base protection. Instead of attempting to reestablish U.S. air bases as sanctuaries from enemy attack, the U.S. Air Force ought to embrace new operational concepts and capabilities for employing airpower early in a war. First and foremost, the United States—alongside allies and partners—should leverage this age of precision weapons *en masse* to strategic and operational advantage, employing a strategy of air denial early in a war. Second, and to support those allies and partners, the service should build an "inside" air force capable of supporting allied- and partner-led air denial operations within the First Island Chain.[18] This inside air force should be built around large numbers of attritable, mobile, and runway-independent platforms rather than traditional fighters and bombers. Finally, the United States will also need to prioritize logistics and sustainment to ensure this inside air force is capable of remaining in the fight.[19] Doing so requires more investment in prepositioned stockpiles and infrastructure improvements, including upgrades to civilian airfields in the Pacific.

This report begins with an overview of the growing threat from the PLA's land-based conventional ballistic and cruise missiles to U.S. air bases in East Asia and beyond, indicating that China appears to have both the capabilities and intent to conduct such attacks in the event of a conflict. It then provides an overview of existing U.S. access to forward bases and runways and the Air Force's efforts to mitigate the threat in the Indo-Pacific. Next, the study models Chinese attacks on U.S. air bases and runways in Japan, Guam, the Northern Marianas Islands, and the Pacific Freely Associated States. After a discussion of data collection and methodology, the report presents its core findings and assesses the effectiveness of alternative mitigation measures, including greater dispersal, reduced runway repair times, and more robust air and missile defense systems protecting bases and runways. It then analyzes the potential effect of plausible Chinese responses to U.S. countermeasures, assessing the effect of missile redeployments, the continued expansion of China's missile arsenal, and alternative targeting strategies. The report concludes with a discussion of the implications of these findings for U.S. defense policy.

PLARF Missile Threats to Air Bases

Chinese Military Strategy and Doctrine

Attacking air bases, airfields, runways, and taxiways is a century-old strategy.[20] No less than the father of airpower theory—the Italian General Giulio Douhet—recommended this strategy, famously concluding, "It is easier and more effective to destroy the enemy's aerial power by destroying his nests and eggs on the ground than to hunt his flying birds in the air."[21] The reason is simple: air bases and airfields are inherently vulnerable as fixed-target locations, especially the long and exposed runways and taxiways that military aircraft require to take off and land. Simply put, it is far easier to destroy fixed installations than to locate, track, and destroy targets on the move. Chinese military strategists seem to have reached this conclusion as well.

Chinese strategy and doctrine portray modern air warfare as a contest between opposing air combat systems—that is, each side's interconnected system of fighters, bombers, surveillance planes, electronic warfare aircraft, aerial refueling tankers, and other support aircraft, as well as the air bases and logistics and sustainment capabilities required to generate sorties—rather than between individual squadrons or weapon platforms.[22] Beijing's perceived path to victory underlying the destruction of combat systems during warfare is simple: The enemy's resistance will collapse once critical nodes in its system cease to function.[23] The 2020 Science of Military Strategy (SMS), an authoritative text published by the PLA's National Defense University, concludes that striking the components of the enemy's combat system not only "reduces and weakens its overall combat capability" but also "shakes and destroys its will to war" and "thus achieves the basic combat objectives quickly at a relatively small cost."[24] Put differently, the PLA favors the indirect approach—striking critical targets that degrade or even paralyze the adversary's entire combat system without ever necessarily defeating the enemy's air superiority fighters in direct combat.[25]

From the PLA's perspective, the critical weak point in the American air combat system is the air base—particularly the runways—required for takeoffs and landings. As a group of Chinese scholars affiliated with the PLA's Academy of Military Science wrote in 2023, the runway is "the most important infrastructure of an airport" because it is where aircraft "undertake the tasks of taxiing, taking off and landing, and parking."[26] For this reason, the SMS calls for attacks on enemy air bases in a bid to "destroy enemy air strike forces" and "undermine enemy air strike plans."[27] Similarly, the Science of Campaigns, a PLA textbook on military operations, proposes a "joint anti-air raid campaign" for attacking and "damaging enemy air fields and runways" in order to "prevent the enemy's early warning aircraft and main battle aircraft from being able to take off."[28]

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The PLARF is expected to play the leading role in conducting such a campaign. In the event of a military conflict, its brigades would most likely launch coordinated missile attacks and re-attacks on U.S. air bases and any other airfields used by U.S. military aircraft within the First and Second Island Chains. The authoritative Science of Second Artillery Campaigns, for example, discusses the PLARF's missile capabilities as "an important means and an indispensable operational focus in our military's joint operations for penetrating the enemy's air defense system, striking the enemy's in-depth targets, and seizing air and naval dominance in future local wars."[29] The PLARF has also conducted training exercises in Western China that appear to practice strikes on airfield mockups resembling Kadena Air Base in Okinawa, Japan.[30] Specifically, these missile strikes would aim to cut and crater runways and taxiways, keeping them closed to aircraft operations until the completion of critical repairs.[31] Subsequent attacks would aim to keep the runways out of service for an extended period and in turn allow the PLA to achieve the window of air superiority it believes it needs to win a quick and decisive victory and deliver a fait accompli.[32]

Chinese Missile Capabilities

China has arrayed dozens of PLARF brigades across the south and east of the mainland (Figure 1) and developed an extensive arsenal of ballistic and cruise missiles capable of carrying ground-penetrating submunitions optimized for attacks on U.S. forward air bases and runways. *The 2023 Report on the Military and Security Developments Involving the People's Republic of China* estimates the PLARF now deploys 200 short-range ballistic missile (SRBM) launchers with 1,000 missiles, 300 medium-range ballistic missile (MRBM) launchers with 1,000 missiles, 250 intermediate-range ballistic missile (IRBM) launchers with 500 missiles, and 150 ground-launched cruise missile (GLCM) launchers with 300 missiles (Table 1).[33]

TABLE 1. PLA Rocket Force

Missile Class	No. Launchers	No. Missiles	Estimated Range (km)
ICBM	500	350	>5,500
IRBM	250	500	3,000-5,500
MRBM	300	1,000	1,000-3,000
SRBM	200	1,000	300-1,000
GLCM	150	300	>1500

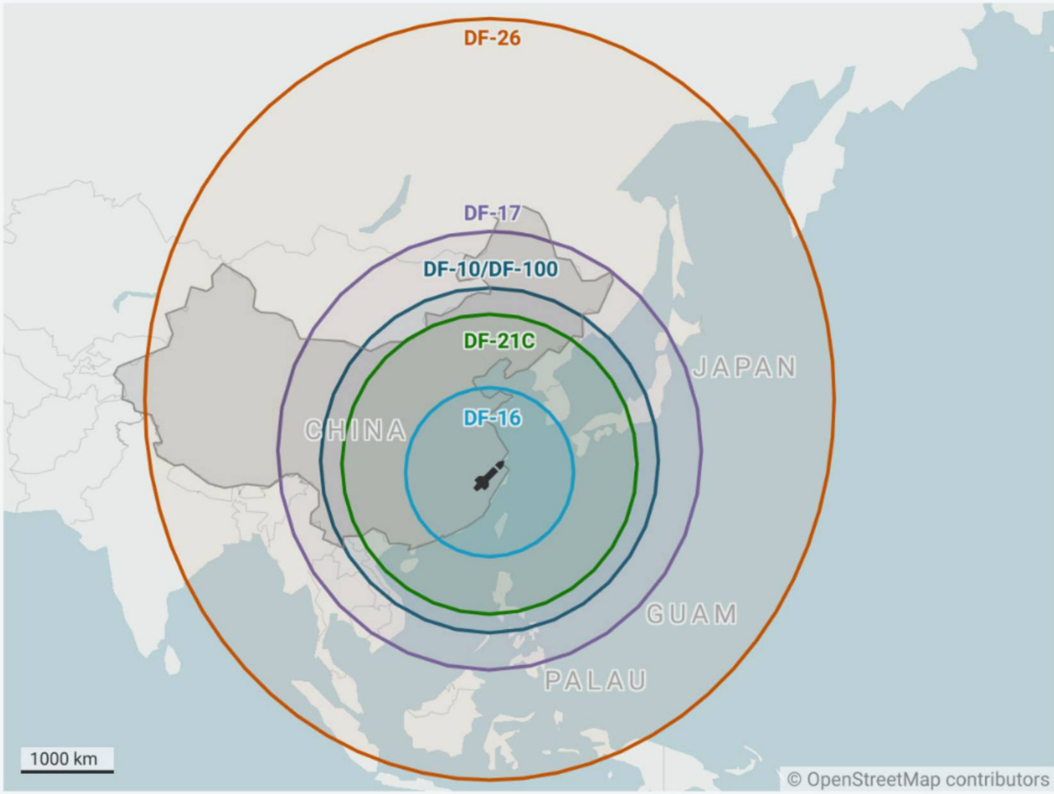
Note: Adapted from a table in the Department of Defense's "2023 Report on the Military and Security Developments Involving the People's Republic of China," 67.

This large and diverse arsenal is not only capable of targeting runways in Japan, but with rapid growth in the inventory of IRBM launchers, it now also increasingly holds U.S. bases and airfields in Guam and other Second Island Chain locations at risk (Figure 2). [34] In the last five years, the PLARF's arsenal of GLCM launchers has nearly doubled, and inventories of MRBM and IRBM launchers have doubled and tripled.[35] The PLARF has two GLCMs—the DF-10 and DF-100, also known as the Changjiang 10 and 100—which it operates from base locations within striking range of most of Japan. In 2020, the PLARF introduced the DF-17 MRBM, which is equipped with a maneuverable hypersonic glide vehicle to make it more difficult for existing U.S. and coalition missile defense systems to intercept.[36]

FIGURE 1. Location of PLARF Missile Brigades

Brigades used in the simulation operate DF-16, DF-17, DF-21C, DF-26, DF-10, or DF-100 missiles and were in range to target at least one runway usable by the U.S. Air Force. Created with Datawrapper.

FIGURE 2. PLARF Missile Ranges



Created with Datawrapper.

China's modernization efforts have also prioritized improving the range, reliability, and accuracy of its missile inventory. The PLARF now has a large SRBM arsenal with improved variants of the DF-11, DF-15, and DF-16. The DF-11 and DF-15, which entered service in the 1990s, have since been replaced with the more accurate DF-11A and DF-15B, in addition to the DF-11AZT and DF-15C armed with earth-penetrating warheads.[37] Similarly, the PLARF is progressively phasing out older DF-21C MRBMs in favor of more modern missiles like the DF-26 IRBM.[38] Dubbed the "Guam Killer" or "Guam Express" because of its potential to strike the U.S. territory, the DF-26 has a 4,000-kilometer range, distinguishing it as China's longest-flying missile capable of conducting conventional strikes.[39]

To fully exploit its missile arsenal, the PLA has also invested heavily in the command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) capabilities required to detect and track targets. The PLA can now field an array of diverse space-based and airborne collection assets—including electro-optic/infrared cameras, synthetic aperture radar, and multispectral sensors—to find and track targets within the First Island Chain and beyond.[40] Though some analysts have questioned whether China can reliably strike moving targets from the mainland, most analysts agree that the PLA has the targeting capabilities to support attacks against fixed targets, such as airfields and runways located in Japan, Guam, and elsewhere within the First and Second Island Chains.[41]

US Air Force Answer: Resilient Forward Basing

The U.S. Air Force is acutely aware of the threat.[42] General James C. Slife, the service's vice chief of staff, recently admitted that the challenge to forward air operations is "considerable." He also succinctly summed up the problem: "When you're fixed to runways there's only so many… aim points that adversary rocket forces have to be able to target."[43] To address this growing threat, the Air Force has committed under its Operational Imperative effort to invest in resilient forward basing.[44] As the Secretary of the Air Force Frank Kendall, Air Force Chief of Staff General David W. Allvin, and Chief of Space Operations General Chance Saltzman testified before the Senate Armed Services Committee in April 2024, "We are… committed to building forward basing resilient enough to enable continued sortie generation, even while under attack."[45]

Agile Combat Employment (ACE)

The cornerstone of the Air Force's approach to resilient forward basing is the concept of Agile Combat Employment. ACE seeks to disperse U.S. aircraft and personnel more widely across the theater, including to multiple—often austere—locations within the First and Second Island Chains.

ACE employs mobility and dispersion to increase the survivability and resiliency of U.S. aircraft and personnel in the face of Chinese missile strikes. As the *Air Force Doctrine Note,* "Agile Combat Employment" explains, "ACE shifts operations from centralized physical infrastructures to a network of smaller, dispersed locations that can complicate adversary planning and provide more options for joint force commanders."[46] Operating from various dispersed locations creates more targets, thereby reducing the likelihood that any single Chinese missile attack or small number of attacks could bring the entire network of U.S. air operations to a screeching halt.[47]

To implement this concept in a contingency, however, Washington would need additional access to bases and airfields in the region.[48] The Air Force confronts two significant challenges in this regard: First, the Indo-Pacific is defined by vast stretches of ocean that both concentrate and limit basing options in ways quite different from the options available in Europe and the Middle East.[49] As General Mike Minihan, the then commander of the U.S. Air Force Air Mobility Command, put it, "You cannot appreciate how much water is out there until you've flown over it for five, 10, 12 hours in a row with no land in sight."[50]

Second, where these maritime expanses give way to land, whether the U.S. Air Force will have permission to use them is an open question. Many regional states—even some close U.S. allies—would prefer to remain on the sidelines in the event of a US-China conflict, opting to restrict or even revoke existing U.S. access agreements.[51] Apart from Japan —which is the most likely country to grant the United States access to bases on its soil, including for conducting strike operations against Chinese forces—the United States has few other options. For example, while the Philippines offered the United States additional access to military bases in 2023, including to three bases in northern Luzon, across the Strait from Taiwan, it has publicly ruled out Washington's using these bases to stockpile weapons or conduct any "offensive action" against China, especially in a war over Taiwan.[52]

> ***Many regional states—even some close U.S. allies—would prefer to remain on the sidelines in the event of a US-China conflict, opting to restrict or even revoke existing U.S. access agreements.***

Similarly, South Korea would most likely restrict the use of U.S. bases on its territory out of concern about North Korean aggression and to avoid a rupture with Beijing, given both its need for China to maintain a restraining hand on Pyongyang, as well as North Korea's extensive trade ties with China.[53] When asked whether U.S. Forces Korea (USFK) might operate from South Korea in a Taiwan contingency, Seoul's defense minister, Shin Won-sik, effectively vetoed the idea, saying, "It is inappropriate to ask a question that presumes USFK will be moved out even if there is a clash surrounding Taiwan. By asking such a question, we might send the wrong signal to the U.S." He added, "The question is not a helpful one for our security. USFK has said nothing like that, and it is an excessive hypothetical. We must firmly say 'No.'"[54] With U.S. basing access severely restricted within the First Island Chain, the United States would have to fly combat missions out of a relatively small number of military runways located in Japan.

The United States would also probably lack the military access required to distribute aircraft and personnel widely within the Second Island Chain, which could serve as a springboard for U.S. air operations. The United States has access to Andersen Air Force Base on the U.S. territory of Guam, as well as to a small number of military runways on the U.S. Commonwealth of the Northern Mariana Islands and Compacts of Free Association arrangements with the Pacific Island states of Micronesia and Palau.[55] Beyond these installations, however, Washington still lacks contingency access in Southeast Asia—namely, in Malaysia, Indonesia, Singapore, and Vietnam.[56] These countries would most likely opt for neutrality in the event of a war between the United States and China, particularly a cross-Strait contingency because they view the Taiwan issue as largely peripheral to their own national security interests, and their economies are deeply dependent on trade with China.[57] Vietnam has long ruled out any foreign military presence on its soil, consistent with its "Four Nos" policy—no alliances, no forward basing, no alignment with a second country against a third, and no use or threats to use force in international relations—while Malaysia and Indonesia have no interest in being seen as taking sides, much less becoming a belligerent in a US-China conflict.[58] Even Singapore, which currently grants U.S. forces rotational access to fly P-8 reconnaissance missions from Paya Lebar Air Base, would probably withdraw those permissions in a military conflict, positioning itself as a neutral broker between the United States and China.[59]

In the absence of access permissions from the Philippines and other Southeast Asian countries—and with South Korea also likely to restrict U.S. military access—the U.S. Air Force would have to rely primarily on a relatively small number of forward military runways in Japan, Guam, the Northern Mariana Islands, and the Pacific Freely Associated States and fly into the theater from far away bases, such as Hawaii and Alaska, as well as northern Australia, assuming Canberra grants permissions.[60] The PLARF thus threatens to array thousands of missiles against fewer than a dozen U.S. air bases or military airfields across the First and Second Island Chains.

US Air Base Defense Capabilities

To defend these forward air bases, the Air Force has backed a mix of active and passive measures, including improved capabilities for rapid runway repair and integrated air and missile defense. The Air Force now has more rapid runway repair methods, and the Army has established Task Force Talon to oversee and coordinate a layered air and missile defense of Guam. Nevertheless, the United States still has critical gaps in terms of capability and capacity for achieving resilient forward basing.

IMAGE 1. The 374th Civil Engineer Squadron Repair a Crater with Flowable-Fill During a RADR Exercise at Yakota Air Base, Japan, August 22, 2024.

Source: Senior Airman Natalie Doan, "CES RADR capability makes quick work of runway repair," 374th Airlift Wing Public Affairs, Yakota Air Base, Japan, August 27, 2024, https://www.yokota.af.mil/News/Photos/igphoto/2003533936/.

An attack on a runway leaves craters, camouflets, spalls, and unexploded explosive ordnance.[61] In 2019, the Air Force implemented Rapid Airfield Damage Recovery (RADR) (Image 1), introducing new materials and methods that cannot only fill more craters faster but also support thousands of combat sorties for both fighters and tankers, unlike the former fiberglass mat repair technique.[62] The RADR process involves three repair phases—rapid damage assessment, rapid explosive hazard mitigation, and rapid damage repair—to reestablish airfield operations. First, engineers identify and assess the damage and presence of explosive hazards. Explosive ordnance disposal (EOD) personnel then clear the repair area, access routes, and equipment and material staging areas of explosive hazards. They may use clearance blades attached to loaders to remove submunitions from paved surfaces or excavators to gain access to deep buried bombs and detonate them from a safe distance.[63]

Finally, once the explosive hazards have been neutralized, teams begin repairing craters and other damage on the operating surface. Repair crews inspect upheaval and remove debris before cutting the pavement around the craters and removing the damaged pavement with excavators. Then they use a cement-like backfill material, known as flowable-fill, and place a rapid-setting concrete or asphalt cap over the excavated area, restoring a smooth surface for aircraft use. The repaired section can support thousands of combat sorties for any combination of U.S. military aircraft before requiring sustainment maintenance. The baseline RADR capability has the personnel, tools, equipment, and vehicles to repair 18 small craters (8.5 ft x 8.5 ft x 2 ft) or two large craters (30 ft x 30 ft x 2 ft) in about six-and-a-half hours, plus the time required for airfield damage assessment and the mitigation of explosive hazards.[64]

Open-source information suggests that the Air Force has an increased capability for RADR, to include a larger cross-section of personnel, or what it calls Multi-Capable Airmen, trained in rapid runway repair, but none of these efforts seem to have included the construction of hardened facilities for storing RADR repair equipment and materials at U.S. bases and airfields in Japan, Guam, the Northern Mariana Islands, and the Pacific Freely Associated States.[65]

> ***It remains an open question whether the U.S. Air Force's mix of passive and active measures will be sufficient to quickly recover sortie generation in a military conflict.***

The Air Force has also stressed the need for more active defense measures, especially enhanced ground-based missile defense systems, to protect U.S. forward bases. "I would feel more confident if we had a more robust active base defense," General Allvin admitted in April 2024, when discussing the Air Force's efforts to implement ACE in the Indo-Pacific.[66] The Army, not the Air Force, however, is responsible for ground defense of air bases. The Army assumed this responsibility with the Key West Agreement of 1948; since then the mission has evolved to include the protection of Air Force bases with ground-based missile defense systems.[67] This uneasy compromise has often been a source of interservice friction, particularly because this mission has often been a low priority for the Army.[68] Army leaders have acknowledged that the Army needs to contribute more to air base defense, with the service looking to grow its number of Patriot missile defense units, including reassigning more soldiers into air and missile defense positions, but progress toward this goal is likely to be slow, given the Army's recruitment challenges and industry's long production timelines.[69]

The Pentagon has also designated the Army as the lead service for building a 360-degree, layered and integrated air and missile defense architecture for Guam.[70] This proposed architecture includes a new and more powerful radar—the AN/TPY-6—and a new Command and Control, Battle Management and Communications System, tied to a land-based variant of the Navy's Aegis Combat System as well as the Terminal High Altitude Area Defense (THAAD), Patriot, and Indirect Fire Protection Capability (IFPC) Increment 2 missile defense systems.[71] This ambitious project, which the U.S. Missile Defense Agency recently scaled back from 22 to 16 sites, is years away from completion, however.[72] As the Department of Defense's Director of Operation Testing and Evaluation annual report warned in 2023, this project faces "significant integration and test planning challenge."[73]

IMAGE 2. THAAD Launcher Offloading From a C-17 Globemaster III at Andersen Air Base, Guam, March 4, 2022.

Source: Sgt. 1st Class David Chapman, "Guam Air Defenders deploy first THAAD remote launch capability," 94th Army Air and Missile Defense Command, Andersen Air Base, Guam, March 16, 2022, https://www.army.mil/article/254576/guam_air_defenders_deploy_first_thaad_remote_launch_capability.

In short, in the coming years, U.S. air base active defense capabilities against Chinese cruise and ballistic missile attacks will remain limited. The Army has two of its seven THAAD batteries deployed in the Indo-Pacific—one in South Korea and the other in Guam. Each battery contains six to nine launch vehicles, with each vehicle carrying eight missiles for intercepting short-, medium-, and intermediate-range ballistic missiles. The United States is reported to have a total of 500 interceptors in its inventory.[74] The Army also has three of its 15 Patriot battalions deployed in the Indo-Pacific—two in South Korea and one at Kadena Air Base in Okinawa, Japan. The Army currently has a stockpile of about 1,200 interceptor missiles to support all global Patriot missile defense operations. Each Patriot battery includes a vehicle, which carries four PAC-2 canisters for engaging ballistic and cruise missile targets, 16 PAC-3, or 14 PAC-3 MSE missiles for intercepting short- and medium-range ballistic missiles.[75] Overall, the small number of launchers in the theater as well as a shortage of interceptor missiles—underscored by the war in Ukraine—would limit U.S. capacity to intercept Chinese missiles and protect U.S. air bases in the region.[76]

Operational Analysis

Could PLARF cruise and ballistic missiles armed with runway-penetrating submunitions keep U.S. air bases and other runways closed to combat air operations—and, if so, for how long? To answer these questions, this analysis models runway attacks, using conservative assumptions and open-source data to estimate the PLARF's order-of-battle and missile capabilities as well as U.S. military access, runway repair times, and missile defense capabilities. The researchers developed a statistical modeling script in Python to calculate the number of hours that Chinese missiles could keep runways closed to U.S. air operations.

Scenario

The model simulates attacks on runways at U.S. bases and airfields in Japan, Guam, the Northern Mariana Islands, and the Pacific Freely Associated States. PLARF ballistic and cruise missiles armed with runway-penetrating submunitions would heave chunks of concrete and crater runway and taxiway surfaces. For China to achieve a runway closure, it would need to crater enough of the runway to deny the minimum operating surface, that is, the minimum length and width of runway necessary for takeoff and landings, depending on the size and type of the aircraft. In addition, China would also likely seek to destroy any long parallel taxiways, which could serve as backup runways to generate sorties. U.S. Air Force mission planning requires a minimum operating surface of 5,000 feet long and 50 feet wide for fighter aircraft and 7,000 feet by 147 feet for larger aircraft, such as tankers (Figure 3).[77] By cutting runways and taxiways in multiple points, Chinese missiles could deny a tanker an undamaged 7,000-by-147-foot runway section and prevent fighter aircraft from operating on unbroken 5,000-by-50-foot stretch of runway or taxiway between damaged areas.

FIGURE 3. Example of Fighter and Tanker Minimum Operating Surfaces (MOS)

Consider Marine Corps Air Station Futenma in Okinawa Japan, which has one runway and one long parallel taxiway—the former is 9,000 by 150 feet, the latter is 8,810 by 75 feet—as an example (Figure 4). The PLARF would need to cut each runway and taxiway in a single, centered place, for a total of two cuts, to ensure fighters lacked the minimum 5,000 feet in runway length required for takeoff and landings. Given the width of the runway and taxiway, the PLARF would also need to sufficiently crater across the width of each to deny the minimum 50 feet of surface required for fighters to take off and recover (Figures 5-6). In the case of larger aircraft, such as tankers, however, a single cut to the runway, if optimally placed, would probably be sufficient to shut down the base (Figure 7).[78] The taxiway would not require any cuts, as it is too narrow and likely lacks the load-bearing capacity to support recurring use by heavier aircraft, like tankers and bombers.

FIGURE 4. Marine Corps Air Station Futenma

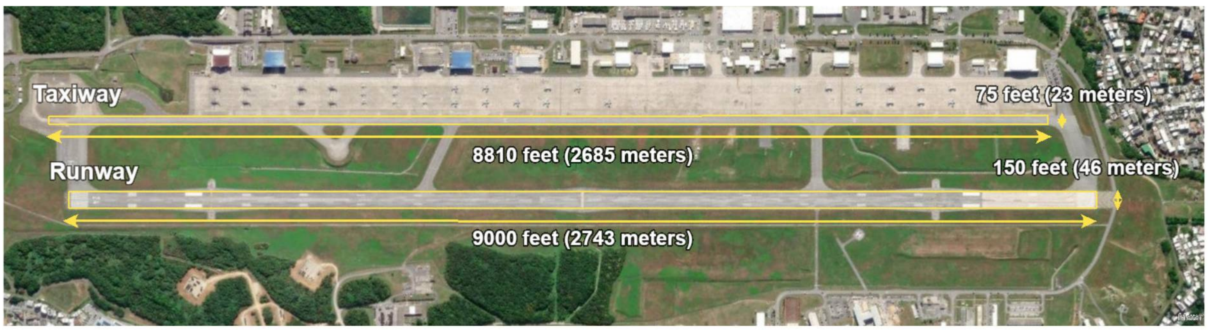


FIGURE 5. Open v. Closed Runway Crater Cuts – Insufficient Cuts

FIGURE 6. Open v. Closed Runway Crater Cuts – Denying Tanker Operations

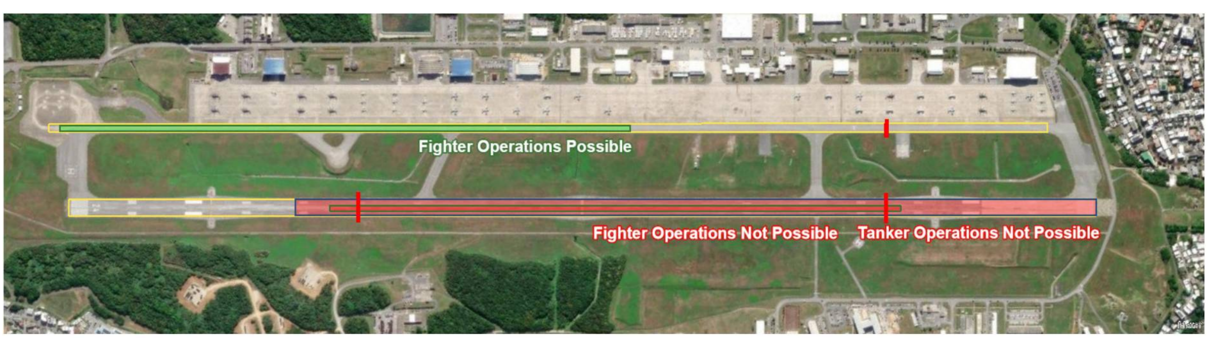


FIGURE 7. Open v. Closed Runway Crater Cuts – Denying All Aircraft Operations

The key question is whether the PLARF has the inventory to launch a large enough attack on all U.S. runways in the region simultaneously to prevent aircraft diversions and continued operations. Another question, given that runways can be repaired, is how many times could China re-attack these sections of runways and taxiways to keep these forward air bases closed.

Methodology

The study developed a statistical modeling script in Python, using a mix of deterministic and random simulations to estimate the number of hours PLARF missile strikes could keep each air base or airfield closed.[79] The model assumes that China aims to achieve at least a 90% chance of destroying all aimpoints and thereby closing all the runways and taxiways at a given air base or airfield (Appendix A). This calculation accounts for several key variables, including the length and width of the runway or taxiway and the size of the minimum operating surface, the reliability and accuracy of Chinese missiles, the effectiveness of missile defense, and the number and dispersal radius of submunitions released by missiles that reach their targets via Monte Carlo simulations (Appendix B).

Using this set of parameters, the modeling script executes a series of simulations to determine the number of hours that Chinese missile attacks could keep air bases and airfields closed to U.S. combat air operations. Attacks on runways and taxiways were simulated as follows: First, China conducts near-simultaneous attacks on all targeted runways in Japan, Guam, the Northern Mariana Islands, and the Pacific Freely Associated States (Figures 8-10). It uses the minimum number of missiles needed to achieve at least a 90% probability of closing the runways at a base or airfield. Second, China prioritizes targets first by their use—U.S. military, then JSDF, then civilian—and then by their proximity to the Taiwan Strait. Third, China assigns the PLARF missile brigade with the shortest-range missile capable of striking the target. Fourth, China re-attacks runways as soon as the United States completes rapid runway repairs.[80] For the purposes of modeling, the analysis assumes the Chinese have perfect intelligence and battle damage assessments (BDAs) to facilitate re-attacking repaired runway sections.[81] To account for explosive ordnance disposal, it also estimates a U.S. repair time of eight hours for a single runway.[82] Finally, the simulation iterates runway attacks until China exhausts its missile stockpiles or there are no more runways or taxiways to target, because they exceed the range of the PLARF's remaining missiles or closure times reach over 2,000 hours.[83]

Photo by Senior Airman Amir R. Young

Results: Chinese Missile Attacks on US Runways

Table 2 presents the results of Chinese attacks on runways and taxiways exclusively at U.S. air bases and airfields in Japan, Guam, the Northern Mariana Islands, and the Pacific Freely Associated States, using baseline assumptions.[84] The simulation shows that PLARF runway attacks exhaust U.S. and Japanese missile defense interceptors within the first 24 hours and close U.S. bases to fighter operations for at least 280 hours (11.7 days) in Japan and 40 hours (1.7 days) in Guam and other Pacific locations. Also important, PLARF missile strikes keep runways closed to tankers and other large aircraft, such as bombers, for a minimum of 800 hours (33.3 days) in Japan and 96 hours (four days) at bases in Guam and elsewhere.

TABLE 2. U.S. Air Bases and Airfields—Shortest Closure Time

Operation Type	Japan	Guam & Pacific Islands
Fighter	280 hours (11.7 days)	40 hours (1.7 days)
Tanker	800 hours (33.3 days)	96 hours (4 days)

To assess the robustness of the baseline results, the research team ran the model across varying key parameter values and assumptions. The results showed the greatest changes occurred when the reliability, accuracy, range, and payload capacity of Chinese missiles and submunitions were altered, as well as when missile defense interception rates varied. After adjusting these variables—reducing missile reliability to 85%, submunition reliability to 95%, and the accuracy of the DF-16 and DF-17 as well as the DF-10 and DF-100 by half—the shortest closure times for fighter and tanker operations fell by up to 40%. In contrast, the results were less sensitive to changing the political assumptions around access permissions. Specifically, if Tokyo proved unwilling to grant Washington permission to conduct operations from U.S. air bases on Japanese soil and China turned all its missiles on U.S. bases in Guam and other Pacific islands, minimum closure times for fighters and tankers would be unchanged. This result is unsurprising because most Chinese missiles cannot reach targets in the Second Island Chain. Moreover, without access to U.S. bases in Japan, fighter sortie generation rates could fall significantly, given the number of available runways and taxiways decreases by nearly half, and fighters operating from Guam and other Pacific Islands would need to traverse long distances to reach targets in the Taiwan Strait.

IMAGE 3. Patriot PAC-3 MSE Missile Launch Test.

Source: John Hamilton, “Patriot Launch,” U.S. Army, White Sands Missile Range, New Mexico, November 29, 2012, https://www.defense.gov/Multimedia/Photos/igphoto/2002466201/.

The analysis also tested a range of missile defense interception rates. If the United States had only a roughly 40% chance of successfully intercepting an incoming Chinese missile with one interceptor, the shortest closure time for fighter operations would stand at 296 hours (12.3 days) in Japan and 40 hours (1.7 days) in Guam and other locations. Similarly, the shortest closure time for tanker operations rose to 816 hours (34 days) in Japan and to 96 hours (four days) in Guam and other Pacific islands. A more robust 80% probability of successfully intercepting an incoming Chinese missile would fix the shortest closure time at 256 hours (10.7 days) for fighter operations and 792 hours (33 days) for tanker operations in Japan. Because the United States has a relatively small number of THAAD interceptors, the results remain unchanged for minimum closure times in Guam and other Pacific islands even with a higher interception rate.

In contrast, denying China the ability to do battle damage assessments—such that the PLARF would be required to strike all aimpoints in follow-up attacks—had a marginal effect on the results. When China re-attacked each aimpoint every eight hours, the shortest closure time for fighter operations dropped to 208 hours (8.7 days) in Japan and 32 hours (1.3 days) elsewhere in the region, with no change in tanker closure times.

Discussion of Chinese Missile Attacks on US Runways

In 2021, General Charles Q. Brown, Jr., then the chief of staff of the Air Force and the current chairman of the joint chiefs of staff, made a startling prediction: the PLA Air Force could overcome U.S. air superiority by 2035.[85] The Defense Intelligence Agency had issued a similarly dire prediction five years earlier, assessing that China was "on the verge of fielding some of the most modern weapon systems in the world," and warning, "In some areas, it already leads the world."[86] The above findings suggest that China could possibly be significantly further ahead than DIA assessed: In 2024, Beijing may well be capable of denying air superiority to the United States through the indirect approach without ever needing to take on U.S. air superior fighters in direct combat.

> ***Repeated Chinese attacks on existing U.S. runways and taxiways in Japan, Guam, and other Pacific locations could prevent effective sortie generation in the early days—and even weeks—of a military conflict.***

The United States would not be able to operate fighter aircraft from U.S. bases in Japan for close to the first two weeks of a conflict, including in the two most strategically significant bases for U.S. fighter operations in the region—Kadena Air Base, which hosts two U.S. Air Force fighter squadrons, and Marine Corps Air Station Futenma, which also operates fighters. These two locations are the closest U.S. military runways to the Taiwan Strait and East and South China Seas, and the only ones from which U.S. fifth-generation fighters would be able to complete their missions and return to U.S. bases without in-flight refueling. With an average combat radius of 600 nautical miles, even fighters operating from Okinawa, Japan, would push their operational ranges, particularly given common combat tactics—like traveling at supersonic speeds or planning routes around known and emerging threats, which use more fuel.[87] Given that these aircraft would not have much loiter time to locate and engage targets, the United States would have no choice but to maintain fewer fighters on station at any given time, reducing the effectiveness of any combat air patrol at the outset of a conflict.[88] These fighters would also assume the risk that as they egress to base, China might have held some missiles back and attack the air base again. Lacking another nearby airfield, fighters would have enough fuel to wait hours while the runway was repaired and would most likely have insufficient range after the mission to fly to another U.S. air base.

Though refueling fighters in flight would extend their operational ranges, the tankers carrying fuel from bases in Japan or Guam might arrive too late at the fight. The United States could generate combat and support sorties, including surveillance aircraft and aerial refueling tankers, from Andersen Air Base in Guam by the fifth day of a war, but operating refueling tankers from a small number of bases within the Second Island Chain would create two significant operational problems. First, the long distances involved would drive up fuel requirements for tankers, reducing what is available to offload to fighters and other receiving aircraft and significantly increasing the number of tankers needed to support combat operations.[89] The United States' tanker fleet, which is already stretched thin in peacetime, lacks the spare capacity to meet wartime demands.[90]

Second, these low-flying and slow-moving tankers are already vulnerable to Chinese air-to-air and surface-to-air missiles, but they would be especially easy for China to detect and shoot down when flying predictable flight routes from known bases. If the United States sent tankers forward from Guam to refuel fighters launched from U.S. bases in Japan, for example, China would not even need radar—it would only need an operative on the ground with a stopwatch to predict the rendezvous time. With such advanced notice, the PLA could wait several hours, luring U.S. fighters into the air and beyond their combat ranges, before shooting down the tanker. The shootdown would result in the loss not only of the tanker itself, but also the fighter aircraft dependent on its onboard fuel.[91] Put differently, so long as China denies the United States the use of runways to launch and—especially—recover aerial refueling tankers from air bases in Japan, it has a window of upwards of 30 days to achieve air denial, if not air superiority, to accomplish its miliary objectives and possibly even to deliver a fait accompli, without the need to defeat U.S. air superiority fighters in combat.

Equally important, the bulk of U.S. airpower would not be available early in a war with China. U.S. military plans depend critically on long-range bombers delivering large volumes of fire early in a war, particularly in the event of a Chinese invasion of Taiwan. China's invasion fleet would be at its most vulnerable while traveling across the Taiwan Strait. This is why most U.S. military leaders and defense analysts emphasize rapidly delivering a large volume of anti-ship missiles to sink as many PLA warships and landing craft as possible within the first 72 hours of any invasion attempt.[92] The goal of these strikes would be to reduce the number of Chinese attackers that Taiwanese defenders have to face on Taiwan's beaches and at its ports. Chinese missiles, however, are likely to keep Andersen Air Base—a strategic hub in Guam for U.S. bomber operations—closed for at least the first three days of any war. The United States could still launch bombers from northern Australia, assuming it has Canberra's permission, or even from Hawaii, Alaska, and parts of the continental United States, but the long distances involved would greatly reduce sortie-generation rates while driving up the number of tankers required and the scale and complexity of operations.[93]

> ***Short of reimagining the operational concepts and capabilities for the employment of American airpower early in a conflict, the U.S. Air Force could find itself an observer, rather than an active fighting participant, at the immediate outset of a war with China.***

These results are based on the optimistic assumptions that runway repairs occur at a steady rate of eight hours, even though personnel losses, equipment breakdowns, and sheer fatigue would make it difficult for repair crews to maintain this operational tempo under sustained attacks.[94] These results also assume that the United States has all the necessary personnel, repair equipment, and materiel prepositioned at U.S. bases and airfields prior to the onset of hostilities. That assumption is wildly optimistic. Even if very large kits were prepositioned at each U.S. air base in the region, these bases would quickly require resupply of the rapid-setting concrete material. The payload of each Chinese missile determines the number of submunitions it can carry inside it. Chinese missiles were simulated to launch about 30 submunitions on average. Given that a large RADR kit can repair 126 small craters—approximately the same size as a submunition crater—even if only half of China's submunitions end up cratering the runway, the United States would exhaust its supply of fillable material after only eight Chinese missiles had struck the runway at an air base.[95] Worse still, the damaged runways would prevent easy resupply of these bases, ruling out the use of U.S. Air Force cargo aircraft.

Assessing US Countermeasures

This section evaluates the effectiveness of proposed countermeasures to enable sortie generation while an air base is undergoing PLARF runway attacks. No single countermeasure is sufficient to address this threat. Even a combination of dispersing U.S. forces across both military and civilian runways in Japan, Guam, the Northern Mariana Islands, and the Pacific Freely Associated States, as well as more robust ground-based missile defenses and shortened repair times would *still* be insufficient to counter PLARF runway attacks. Moreover, no combination of countermeasures would allow the United States to generate effective combat and support sorties in the opening days of a conflict.

Dispersed Forward Basing

ACE's core concept is the distribution of aircraft and personnel to smaller, dispersed forward operating locations. Instead of operating from a small number of large bases, the Air Force intends to distribute air operations between large "hub" bases and a series of "spoke" contingency locations.[96] This "hub-and-spoke" model aims to thin out the size of incoming missile salvos, effectively reducing the damage to runways and taxiways and, in turn, enabling continued sortie generation. Accordingly, the United States has been rehabilitating old airfields that were last used in World War II—including the North Airfield on Tinian Island—to serve as "spokes" to Andersen Air Base in Guam.[97] Given that regional political realities limit options for basing in a contingency, defense analysts inside and outside the Pentagon have also proposed distributing U.S. assets more widely within Japan—including JSDF bases and possibly even civilian airfields—in the event of a war with China (Figures 8-10).[98]

FIGURE 8. U.S. Air Bases and Military Airfields, JSDF Bases, and Civilian Airports in Japan

Only airfields with at least one runway suitable for fighter operations were included. Joint-use airfields were marked as military bases. Created with Datawrapper.

FIGURE 9. U.S. Military and Civilian Airfields in the Mariana Islands (including Guam)

Only airfields with at least one runway suitable for fighter operations were included.
Joint-use airfields were marked as military bases. Created with Datawrapper.

FIGURE 10. U.S. Military and Civilian Airfields in Palau

Only airfields with at least one runway suitable for fighter operations were included.
Joint-use airfields were marked as military bases. Created with Datawrapper.

In the event of a military conflict, the United States would request permission from the government of Japan to use JSDF bases and facilities consistent with Article VI of the 1960 Treaty of Mutual Cooperation and Security with Japan. This treaty grants the United States "the use by its land, air and naval forces of facilities and areas in Japan."[99] A separate Status of Forces Agreement (SOFA) sets the conditions for U.S. military access and use, providing for not only the exclusive use of U.S. bases but also for the use of Japanese facilities for "limited periods of time."[100] The United States could also ask Tokyo to grant permission for the use of civilian airports, but the Japanese government only has the legal authority to grant those permissions if it has declared an armed attack to be imminent or to have already taken place, which provides China the chance to get in a first volley.[101]

Table 3 shows the results of dispersing U.S. aircraft and personnel more widely across Japan, Guam, and other Pacific islands, using the same baseline assumptions and estimating repair times of 24 hours at JSDF bases and three weeks at civilian airfields.[102] If the United States were to have permission to distribute assets and generate sorties from JSDF runways and taxiways, as well as civilian airfields located in Guam and the other Pacific islands, and assuming Japan provided the Patriot batteries to protect any combined US-JSDF bases, the shortest closure time would decline by roughly 70%— or 88 hours (3.3 days) for fighter operations and 232 hours (eleven days) for tanker operations. The results remain largely unchanged outside Japan—32 hours (1.3 days) for fighters and 88 hours (3.3 days) for tankers—because there are so few civilian airfields in Guam, the Northern Mariana Islands, and the Pacific Freely Associated States.

TABLE 3. Operations Dispersed to JSDF Bases in Japan & Civilian Airfields in the Pacific Islands—Shortest Runway Closure Time

Operation Type	Japan	Guam & Pacific Islands
Fighter	88 hours (3.7 days)	32 hours (1.3 days)
Tanker	232 hours (9.7 days)	88 hours (3.7 days)

Table 4 presents the results of still greater base distribution, assuming the United States receives permission from Tokyo to use not only JSDF bases but also civilian runways and taxiways across Japan, and Japan employs 14 PAC-3 batteries to protect runways at JSDF bases. Under this scenario, despite the addition of 55 civilian airfields, PLARF missile strikes keep fighters grounded in Japan for a minimum of 72 hours (three days) and tanker operations halted in the country for no less than 216 hours (nine days). The results for bases and airfields located outside Japan do not change. Maximizing distribution within Japan and other places where the United States has guaranteed access will thus not be sufficient to keep airfields open early in a war. The United States will need other active and passive measures to ensure sufficient combat sortie generation.

TABLE 4. Operations Dispersed to JSDF Bases in Japan & Civilian Airfields in Japan and the Pacific Islands—Shortest Runway Closure Time

Operation Type	Japan	Guam & Pacific Islands
Fighter	72 hours (3 days)	32 hours (1.3 days)
Tanker	216 hours (9 days)	88 hours (3.7 days)

Rapid Runway Repair Times

One such measure is shortened runway repair capabilities, particularly building up capabilities and capacity at JSDF bases and civilian airfields. According to interviews with current and former JASDF senior leaders, Japan has purchased equivalent RADR kits for the JSDF, but it lacks both the personnel and materiel to undertake rapid runway repairs at scale in response to concurrent missile attacks on its bases. If Japan adopted similar concepts and invested more resources in runway repair kits and training, it might be able to shorten repair times at JSDF bases.[103] The U.S. Air Force has also developed the Multi-Capable Airmen concept, in which personnel are trained to perform key tasks outside of their core specialty, including combat support and runway repair operations (Image 2).[104] The idea is for civil engineers, along with maintenance, finance, medical, and operations support personnel, to fill craters and conduct other runway repairs, expediting the continued generation of sorties in wartime. If these additional personnel or alternative techniques reduced the time required for repairs, China would be required to re-attack repaired surface sections more frequently, shortening the total number of hours it could keep U.S. aircraft grounded.

IMAGE 4. Airmen From Various U.S. Air Force Specialties Practice Runway Repair During a Multi-Capable Airmen Exercise at Dobbins Air Reserve Base, Georgia, May 22-24, 2023.

Source: John Goddin, "AFCEC successfully tests Multi-Capable Airmen airfield repair concept," Air Force Installation and Mission Support Center Public Affairs, Joint Base San Antonio-Lackland, June 2, 2023, https://www.af.mil/News/Article-Display/Article/3415267/afcec-successfully-tests-multi-capable-airmen-airfield-repair-concept/.

To assess the impact of shorter repair times, the model reduced repair times to eight hours at JSDF bases and 24 hours at all civilian airfields, assuming a dispersed force posture while holding all other baseline parameters constant. Table 5 presents the results, showing that the shortest closure times drop to 24 hours (one day) for fighter operations across the theater, 88 hours (3.7 days) for tanker operations in Japan, and 80 hours (3.3 days) for tanker operations outside Japan. Shortened repair times combined with a dispersed force posture, thus decrease closure times for fighter and tanker operations in Japan by some 60% or more compared to the use of dispersal alone. The results are up to 25% shorter for bases and airfields located outside Japan.

TABLE 5. Faster Runway Repair—Shortest Runway Closure Time

Dispersion	Operation Type	Japan	Guam & Pacific Islands
+ JSDF + Pacific Island Civilian Airfields	Fighter	48 hours (2 days)	32 hours (1.3 days)
	Tanker	136 hours (5.7 days)	80 hours (3.3 days)
+ Japan Civilian Airfields	Fighter	24 hours (1 day)	24 hours (1 day)
	Tanker	88 hours (3.7 days)	80 hours (3.3 days)

Note: Repair times are assumed to be eight hours for U.S. military bases/JSDF bases and 24 hours for civilian airfields

Missile Defense

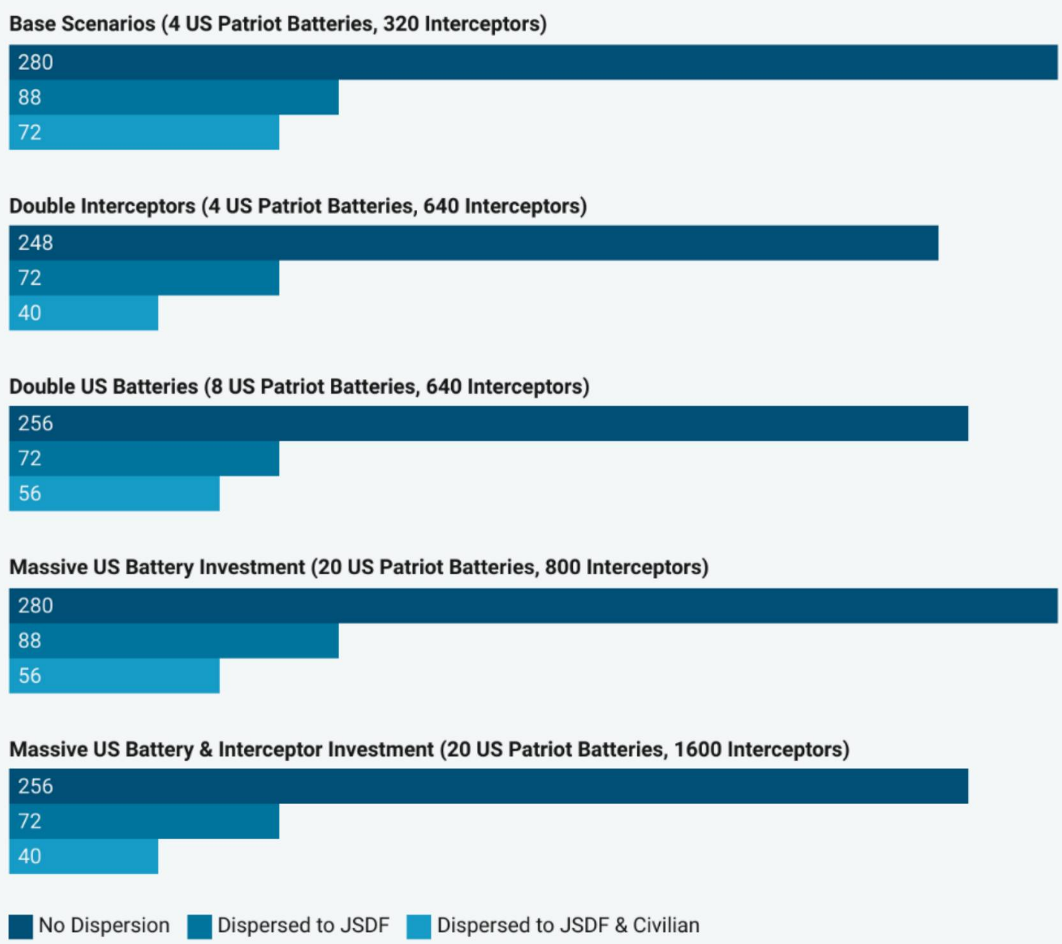
The most commonly proposed policy option to address the threat to U.S. bases in the Pacific is building a more robust missile defense architecture. Figures 11 and 12 show the results for different missile defense investment options, using the same baseline assumptions as above. One option is to expand U.S. missile interceptor stockpiles in the theater to allow U.S. Patriot and THAAD batteries to intercept more incoming Chinese missiles. If the United States doubled the number of Patriot and THAAD interceptors, for example, closure times for fighters and tankers would decrease between 15 and 45% across bases and airfields in Japan, Guam, and other locations. The small change reflects the high expenditure rate of interceptors. Even after doubling the number of interceptors, the United States would still run out of missiles within 56 hours into the start of a conflict, according to the shortest estimate.

Another option is to deploy more missile defense batteries to protect more bases and airfields in the region. If the United States acquired more missile defense systems and allocated more military personnel to missile defense batteries, China would have to use larger missile salvos to be sure its missiles still had at least a 90% chance of successfully denying the United States the minimum operating surface required for the launch and recovery of U.S. combat and support aircraft. If the United States quadrupled the number of Patriot batteries protecting runways in Japan—deploying 20 Patriot batteries equipped with a total of 1,600 interceptors—in combination with a dispersed force posture, it still could not generate fighter sorties for a minimum of 40 hours (1.7 days) and tanker operations for at least the first 184 hours (7.7 days) of any conflict. This more robust missile defense posture, when combined with a dispersed force posture, would shorten closure times about 45% for fighter operations and 15% for tanker operations in Japan.

Employing a mix of these countermeasures—a dispersed force posture in combination with shorter repair times and more robust missile defense capabilities—closes fighter operations for a minimum of 24 hours (one day) and tanker operations for at least 64 hours (2.7 days) in Japan. For all other locations, including Guam, closure times similarly drop to at least 24 hours (one day) for fighters and 64 hours (2.7 days) for tankers.

FIGURE 11. Missile Defense Investments—Fighter Operations

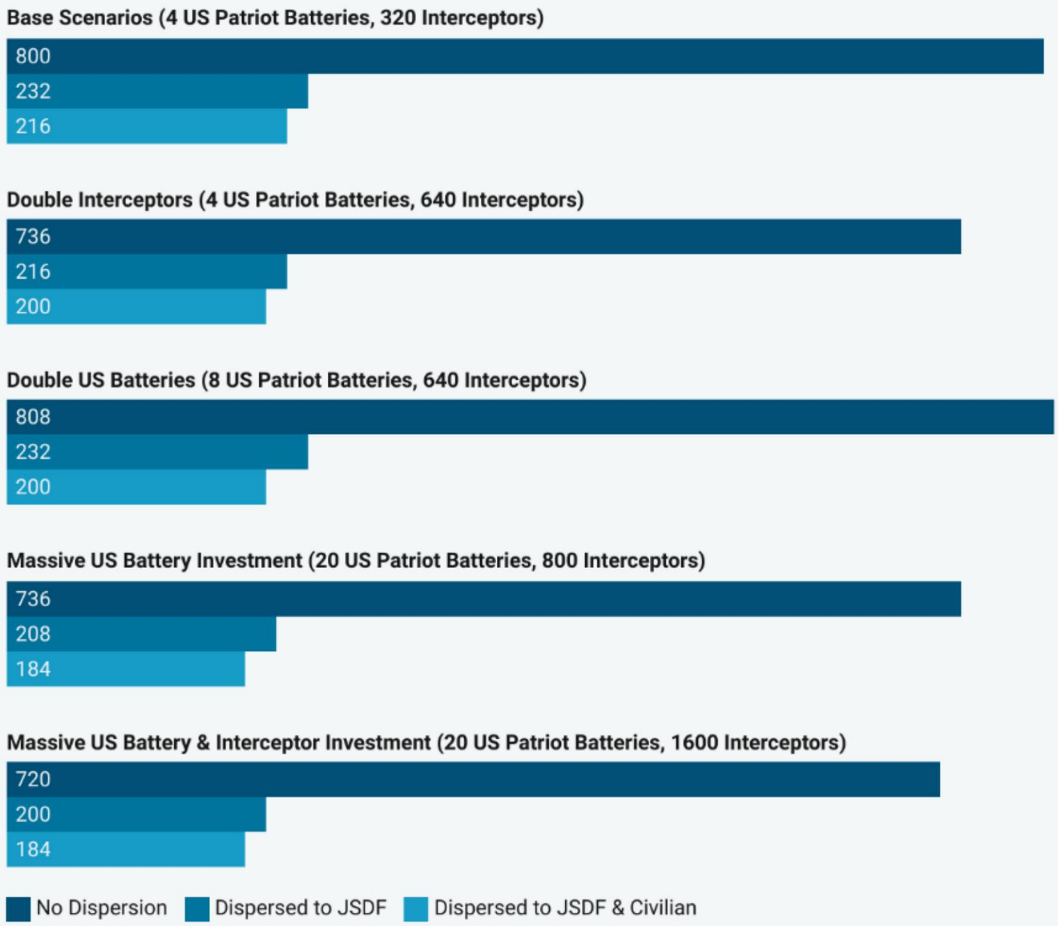
Hours until the first airfield in Japan reopens for fighter operations



Created with Datawrapper.

FIGURE 12. Missile Defense Investments—Tanker Operations

Hours until the first airfield in Japan reopens for tanker operations



Created with Datawrapper.

In sum, a more robust missile defense architecture would reduce closure times, but even a substantial buildup of U.S. missile defense capabilities in the region would be unlikely to solve the problem. Worse still, even employing a combination of passive and active countermeasures almost certainly would be insufficient to ensure the United States can project airpower effectively at the outset of a war.

Discussion of US Countermeasures

Chinese missile attacks on air bases and airfields in Japan, Guam, and other Pacific islands would almost certainly prevent the effective use of American airpower in the critical first days of a war, even if the United States and Japan increased their investments to counter the threat. That said, Washington and Tokyo ought to step up investments to better prepare the U.S. military and JSDF for this challenging operational environment. Those efforts should focus on minimizing—not eliminating—disruptions to the U.S. ability to project airpower in a war. The results of this study offer some guidance about where the United States should target those investments, suggesting the greatest benefits relative to cost will come from distributing to JSDF bases and civilian runways in Guam, the Northern Mariana Islands, and the Pacific Freely Associated States—but not Japanese civilian airfields—and improving U.S. and Japanese runway repair capabilities.

The results validate that the ACE concept—dispersing U.S. aircraft and personnel more widely across multiple locations—has the largest effect on shortening the window of time when the United States cannot use air bases and airfields in the region. Equally important, the results also suggest that adding more and more reserve bases and alternate airfields would yield marginal gains and, in the end, may not be worth the added cost and logistical complications to operate from civilian airfields in Japan. The JSDF has identified dozens of civilian airports for potential military use, but they require significant upgrades to their infrastructure if they are to support military operations.[105] Specifically, most civilian airfields lack the specialized equipment, military-grade fuel, trained personnel, RADR kits, communications systems, and spare parts needed to support military operations. Given the size of these items and the challenges associated with moving cargo in a contested environment, deploying these items after a crisis or conflict starts might not be feasible.[106]

Many local governments, however, are unlikely to permit the United States to preposition equipment and supplies at civilian airfields in peacetime, given that the Japanese public is wary of these airfields becoming potential targets for attack.[107] It may not be worth the cost and risks to the political cohesion of the US-Japan alliance to push the issue of the U.S. military's using civilian airfields in wartime—and taking the necessary steps now to prepare those airfields for that possible use. Pushing this issue would shorten closure times in Japan by only 16 hours for either fighter or tanker operations, still keeping runways closed in the critical early days of a military conflict.

Instead, the results suggest that the United States and Japan ought to prioritize efforts aimed at shortening runway repair times. The U.S. Air Force—to its credit—has made progress in this area in recent years, training more Airmen and conducting more exercises, including with Japan, to improve the readiness of the force to repair runways under attack. That said, there are still not enough civil engineers or explosive ordnance personnel to support a dispersed air force posture in the Indo-Pacific. Currently, the U.S. Marines have two Marine Wing Support Squadrons (MWSSs) based in Japan, and the Air Force has the 554th Red Horse Squadron deployed to Guam.[108] Even with the Multi-Capable Airmen concept, civil engineers still need to be on site to oversee and direct runway repairs, and only EOD personnel have the specialized training to clear hazards.

Simultaneous Chinese missile attacks on runways and taxiways in Japan, Guam, and other locations would quickly overstretch the U.S. military's engineering and EOD capacity. The Army might be able to offer additional support, but these units would need to receive training and deploy to forward air bases before the onset of hostilities.[109] The current U.S. capacity to conduct rapid runway repair would thus almost certainly fall short of meeting the eight-hour repair times assumed in this analysis, suggesting the results of this study are optimistic and more aspirational than a reflection of the current situation.

> ***The U.S. Air Force might need more pilots and next-generation technologies and platforms, but it needs engineers and EOD personnel armed with concrete at least as much, if not more, to generate effective airpower in the Indo-Pacific.***

During the Cold War, the United States and its NATO allies chose to invest more heavily in logistics and combat support compared to the Soviet Union and its Warsaw Pact allies, because they recognized that superior logistics and support assets underwrote NATO's deterrence and defense.[110] The U.S. Air Force—and the broader Joint Force—ought to urgently relearn this lesson. The policy debate tends to focus on next-generation technologies and platforms, but support functions—like runway repair and aerial refueling capabilities —are likely to play a larger role in deterring a possible Chinese attack on Taiwan.

Like the U.S. Air Force, Japan ought to invest more time and resources to scale up its ability to conduct rapid runway repairs at JSDF bases, as doing so could ensure closure times in Japan fall over 40% for fighter and tanker operations. To make this a reality, however, Japan would probably need to embrace the Multi-Capable Airmen concept and increase training exercises. It would also need to acquire large numbers of RADR kits and build hardened facilities in which to store them. Ideally, Japan could produce these kits, particularly the rapid-setting concrete, on its territory, avoiding the need to transport this bulky cargo across the Pacific Ocean and making resupply easier in wartime.

Finally, the results of this analysis suggest that building a more robust missile defense posture to protect runways in the Indo-Pacific is likely to fall short—and probably would not be the best use of these systems or the investment of additional resources. To be sure, U.S. missile defense systems are now more capable than their predecessors, but they are also more expensive. Each Patriot battery costs about $1.1 billion dollars, and each PAC-3 interceptor missile costs about $4 million.[111] THAAD is slightly less costly at $74 million per battery but its interceptor missiles are expensive at $9.4 million apiece.[112] More to the point, these air defense systems tend to put the United States on the wrong end of the cost curve. Chinese SRBMs are reported to cost between $500,000 and $2 million apiece. [113] Assuming a cost of $2 million, and a standard shot doctrine of launching two PAC-3 interceptor missiles against a single incoming Chinse missile to maximize the probability of a successful intercept, the result is a cost/exchange ratio of 4:1. This cost imbalance is unsustainable against an adversary like China with large missile stockpiles.

IMAGE 5. US-JSDF Combined RADR Training at Naha Air Base, Japan, March, 14, 2023.

Source: Senior Airman Sebastian Romawac, "18th CES, JASDF conduct RADR training," U.S. Air Force, Naha Air Base, Japan, March 14, 2023, https://www.kadena.af.mil/News/Photos/igphoto/2003182957/.

Moreover, the United States cannot produce interceptors fast enough to keep up with the high expenditure rates. In October 2024, two U.S. navy ships fired about a dozen SM-3 interceptors at Iranian ballistic missiles headed for Israel—expending a year's worth of SM-3 production in a single day.[114] The results of this study warn that the story would be similar in the Indo-Pacific, where the United States would likely run out of Patriot and THAAD interceptors within the first 24 hours of a military conflict. If the United States employed its current entire inventory of 1,200 Patriot missiles, it would employ them all within a couple days. The production of interceptors is already stressed to meet global demand amid the wars in Ukraine and the Middle East and a host of other supply chain and production challenges; U.S. defense manufacturers are much less prepared to produce enough interceptors to keep pace with U.S. wartime needs in the Indo-Pacific.[115] Defense manufacturers produce about 500 Patriot missiles annually at present and are working to increase production to 650 by 2027, but that is the equivalent of a few days' worth of missiles fired to protect fewer than a handful of runways.[116]

> *Without tankers, fighters would have to fly fewer sorties each day.*

The United States might be prepared to make far more substantial and costly investments in missile defense capabilities if doing so would solve the problem discussed in this study. These findings suggest, however, that even a massive buildup of U.S. missile defense capabilities is likely to fall short, even when combined with other countermeasures. Even if the United States grew its Patriot missile defense force—expanding to 20 Patriot batteries and deployed them all to protect runways in Japan—China could still deny the use of these runways by fighters in the first days of a war, and thereafter fighters would have to operate without any tanker support for nearly another week. Without tankers, these fighters would have to fly fewer sorties each day. The operational gains hardly seem to justify the costs, especially because China could easily offset these investments by increasing its missile stocks. Missile defense is a critical U.S. capability—one that merits more investments—but given that these systems and their interceptor missiles are relatively expensive and few in number, a smarter employment strategy would be to reserve them to provide protection for a small number of high-value assets inside the base—like communication facilities, fixed radars, and parked aircraft—that cannot be as easily repaired as runways.[117]

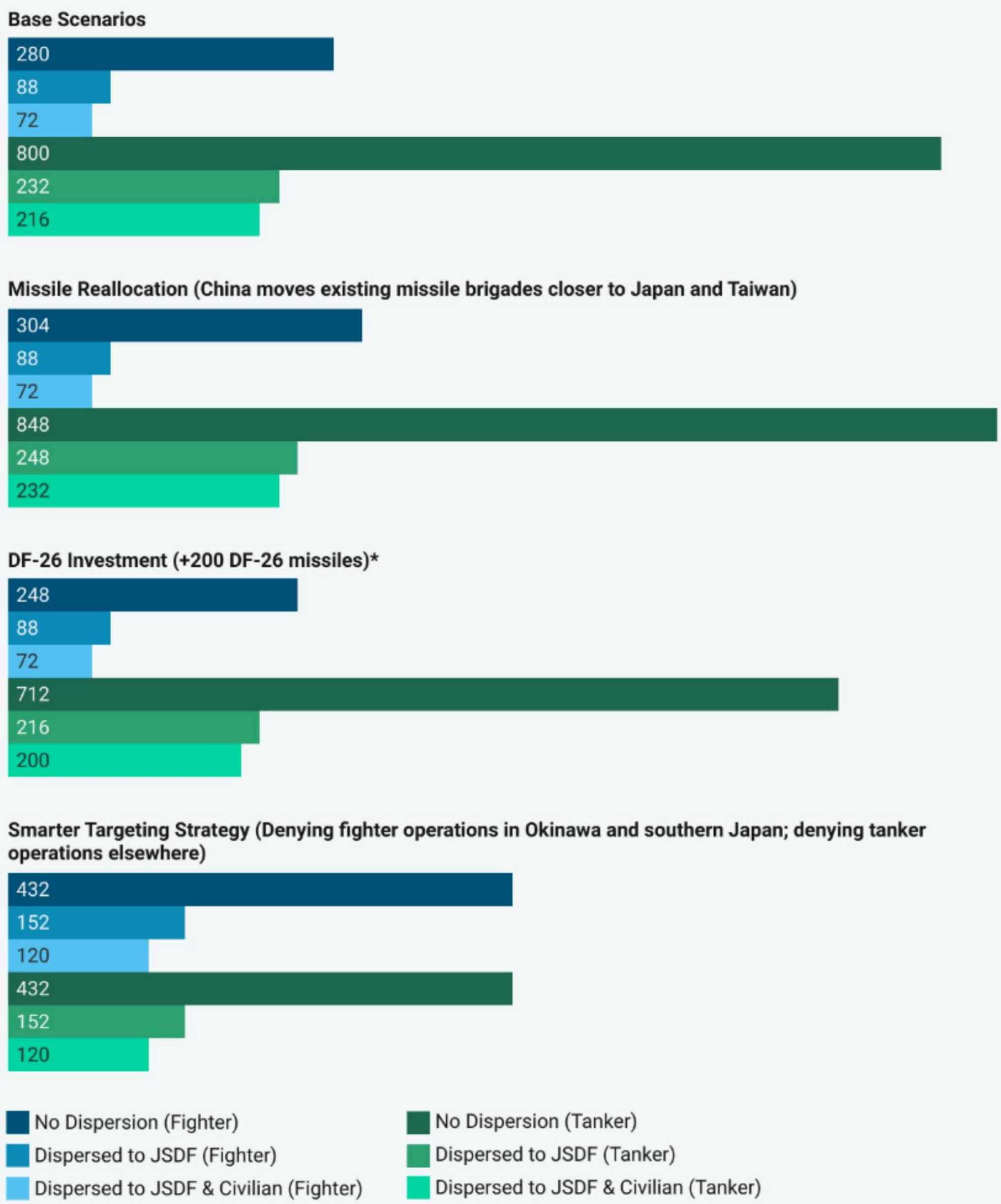
Assessing Potential Chinese Counters

There is an old military adage: "The enemy has a vote." To this point, China would almost certainly respond to any U.S. countermeasures with counteradaptations of its own, seeking to regain the advantage. This section examines some ways that Beijing could adapt its strategy and missile capabilities to lengthen runway closure times (Figures 13-14). A smarter Chinese targeting strategy—one that only denies a minimum operating surface to fighters at those air bases and airfields from which U.S. fifth-generation fighters can reach their targets without requiring in-flight refueling but attacks all others to close them to tanker operations—could push U.S. fighters back or keep them grounded even longer. In addition, China could further extend closure times for tanker operations by redeploying other PLARF brigades currently operating DF-26 IRMBs to be within range of U.S. air bases and airfields or investing to further expand the size of their DF-26 arsenal.

Redeployment of PLARF Brigades

One option available to China is to redeploy existing missiles to increase the threat to runways and taxiways in the region. For instance, China might redeploy some PLARF brigades to bring missiles within range of air bases and runways in Japan, Guam, and other Pacific islands, or allocate more missiles from its total inventory to PLARF brigades already tasked with this mission. These adaptations significantly prolong closure times across the Second Island China but have a more modest effect on closure times in Japan (Table 6). In what amounts to a current worst-case threat scenario, the model was rerun on the assumption that China moves some additional DF-16 SRBM and DF-21 MRBM brigades closer to the coast to bring more of Beijing's missiles within range of targets within Japan, deploys all DF-26 IRBMs to within range of targets in Guam and other Pacific islands, and allocates its entire PLARF missile inventory to the task. In this case, and assuming maximal U.S. dispersal to miliary and civilian facilities, closure times would increase by 32 hours (1.3 days) for fighter operations and 48 hours (two days) for tanker operations, closing runways altogether to fighters for at least 64 hours (2.7 days) and to tankers for a minimum of 136 hours (5.7 days). The effect on the results in Japan is more modest. The shortest closure times in Japan increase by 16 hours for tanker operations and remain the same for fighter operations. This result is unsurprising, given that the majority of the PLARF's missile brigades are distributed across southern or eastern China, already positioning these brigades to hold U.S. military assets in Japan at risk.

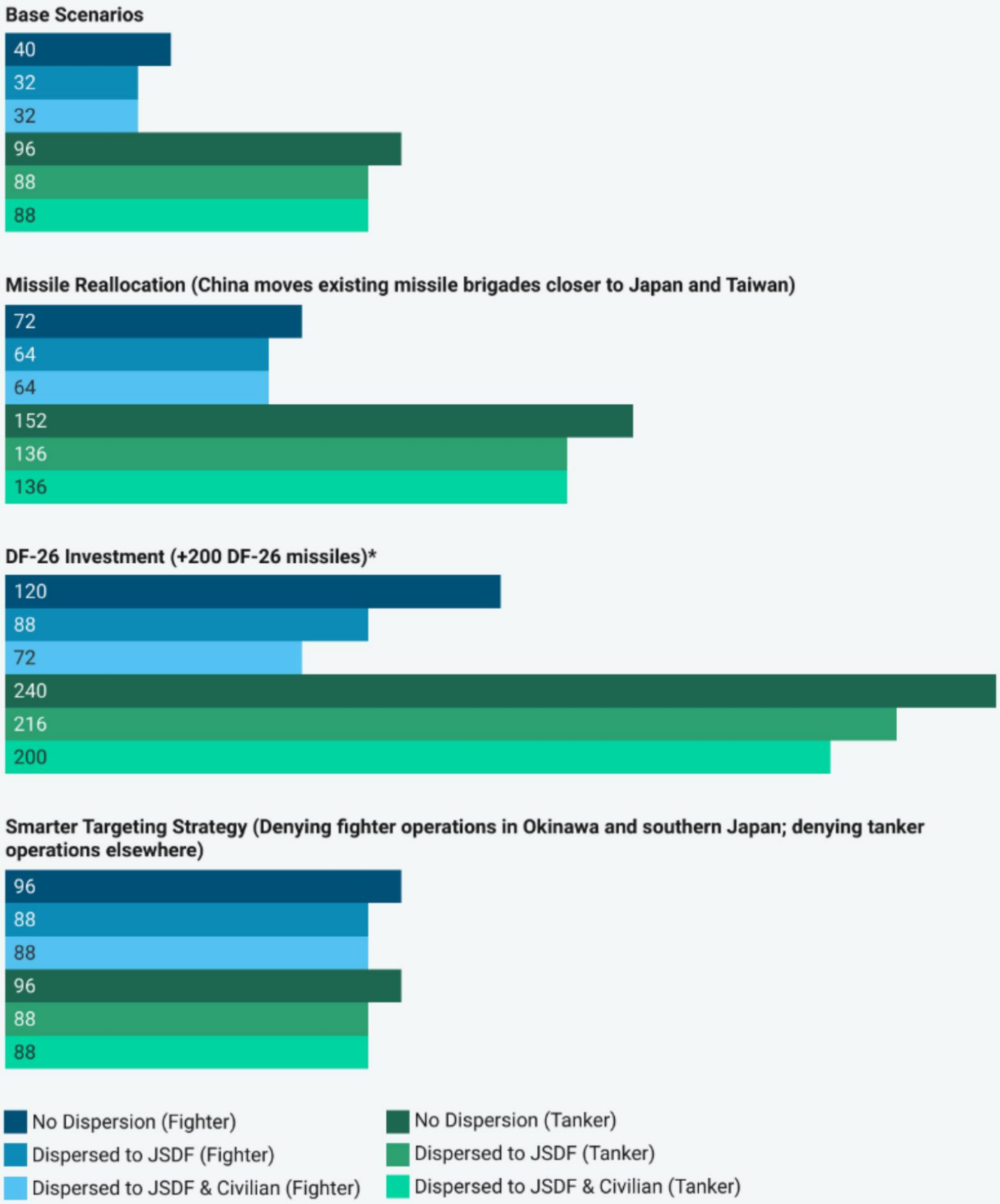
FIGURE 13. Impact of Chinese Counter-Countermeasures in Japan
Hours until the first airfield in Japan reopens to fighter and/or tanker operations



*Investment by China into 200 new DF-26 missiles greatly increases closure times for airfields outside of Japan (in Guam and other Pacific Islands) at the cost of slightly reducing closure times in Japan. Created with Datawrapper.

FIGURE 14. Impact of Chinese Counter-Countermeasures Outside of Japan

Hours until the first airfield in Guam or the other Pacific Islands reopens to fighter and/or tanker operations



*Investment by China into 200 new DF-26 missiles greatly increases closure times for airfields outside of Japan (in Guam and other Pacific Islands) at the cost of slightly reducing closure times in Japan. Created with Datawrapper.

TABLE 6. Redeployment of PLARF Brigades—Shortest Runway Closure Time

Dispersion	Operation Type	Japan	Guam & Pacific Islands
U.S. Bases	Fighter	304 hours (12.7 days)	72 hours (3 days)
	Tanker	848 hours (35.3 days)	152 hours (6.3 days)
+ JSDF + Pacific Island Civilian Airfields	Fighter	88 hours (3.7 days)	64 hours (2.7 days)
	Tanker	248 hours (10.3 days)	136 hours (5.7 days)
+ Japan Civilian Airfields	Fighter	72 hours (3 days)	64 hours (2.7 days)
	Tanker	232 hours (9.7 days)	136 hours (5.7 days)

Further Expansion of PLARF Missile Arsenal

China could also counter any U.S. countermeasures by expanding its missile arsenal. Indeed, Beijing's inventory of DF-26 missiles has continued to grow in recent years, with commercial satellite images from 2023 to 2024 capturing at least 72 additional DF-26 launchers, enough to equip two additional brigades.[118] These developments suggest China is acquiring the capacity to keep runways and taxiways on Guam and other Pacific islands closed for even longer. The results of the model show that even a modest expansion of China's DF-26 arsenal would significantly drive up closure times (Table 7). If China increased its inventory by half, for example, acquiring 200 more DF-26 missiles, minimum closure times at U.S. air bases within the Second Island Chain would rise sharply, by 200% to 120 hours (five days) for fighter operations and by 150% to 240 hours (ten days) for tanker operations. Dispersing to civilian airfields on these islands offsets the impact of the Chinese missile buildup somewhat, but China could still keep these runways and taxiways closed to fighters for at least 72 hours (three days) and to tankers for 200 hours (8.3 days), or more than twice as long as it can currently.

TABLE 7. Additional DF-26 Investment—Shortest Runway Closure Time

Dispersion	Operation Type	Japan	Guam & Pacific Islands
U.S. Bases	Fighter	248 hours (10.3 days)	120 hours (5 days)
	Tanker	712 hours (29.6 days)	240 hours (10 days)
+ JSDF + Pacific Island Civilian Airfields	Fighter	88 hours (3.7 days)	88 hours (3.7 days)
	Tanker	216 hours (9 days)	216 hours (9 days)
+ Japan Civilian Airfields	Fighter	72 hours (3 days)	72 hours (3 days)
	Tanker	200 hours (8.3 days)	200 hours (8.3 days)

A Smarter Chinese Targeting Strategy

Finally, China could opt to change its targeting strategy to close only those air bases and airfields to fifth-generation fighter operations that would enable aircraft to reach their targets without aerial refueling—while keeping all other runways closed to tankers and other large aircraft, like bombers. If China cratered runways and taxiways at U.S. and JASDF air bases and civilian airfields across Okinawa and Southwest Japan to prevent their use by fighters while attacking all other runways in Japan, Guam, and other Pacific islands to prevent tanker operations, minimum closure times for fighter operations would skyrocket in both Japan and Guam (Table 8). If Beijing employed this strategy, and assuming the United States dispersed its aircraft and personnel to both military and civilian locations, China would nearly double the minimum closure time for fighter operations in Japan and more than double it across Guam and other Pacific islands. Of particular concern, the United States would not be able to launch or recover any fighters from Japan for at least the first 120 hours (five days) of a war. The story is similar everywhere else: The United States would not be able to operate any bombers or the tankers—as well as the fighters that depend on their aerial refueling—for at least 88 hours (3.7 days).

TABLE 8. Smarter Runway Targeting Strategy—Shortest Runway Closure Time

Dispersion	Japan	Guam & Pacific Islands
U.S. Bases	432 hours (18 days)	96 hours (4 days)
+ JSDF + Pacific Island Civilian Airfields	152 hours (6.3 days)	88 hours (3.7 days)
+ Japan Civilian Airfields	120 hours (5 days)	88 hours (3.7 days)

Note: Results are based on requirements for fighter operations.

Discussion of Potential Chinese Counters

An air base is no longer a sanctuary from enemy attacks—and no amount of military spending will change that. China could always redeploy existing PLARF brigades or build more or better missiles to offset U.S. and Japanese defenses. Moreover, a smarter Chinese targeting strategy—which would cost nothing—could shut down U.S. fight operations in the region for even longer. By denying the use of runways and taxiways to fighters across Okinawa and Southwest Japan and the use of runways to tankers elsewhere in Japan, as well as Guam and other Pacific islands, China could keep America's most advanced fifth-generation fighters sidelined for at least the first five days of a war.

> ***Instead of hitting all air bases and airfields at once, if China conducted a "random walk" of which bases it hit, and when, the United States would still be able to launch and recover aircraft, but its mission failure rate would rise.***

Moreover, other Chinese targeting strategies could effectively delay and disrupt U.S. air operations in other ways—and potentially for even longer. U.S. combat aircraft typically operate with other aircraft as part of a strike package—that is, a large, mixed, and mutually supporting group of aircraft tasked with a mission, such as sinking an enemy's amphibious landing ships or destroying its forces massed on beaches. U.S. bombers, tankers, and reconnaissance aircraft launched from Andersen Air Base, for example, would likely expect fighter escorts as they approached targets closer to the Taiwan Strait. Planning and coordinating these strike packages is a complex process, one that Chinese missile strikes on U.S. air bases could disrupt.

Instead of hitting all air bases and airfields at once, if China conducted a "random walk" of which bases it hit, and when, the United States would still be able to launch and recover aircraft, but the U.S. mission failure rate would rise.[119] For example, if China attacked the air base where those fighters were located, and they were trapped on the ground at that field, the rest of the strike package relying on those fighters might have to abort. Given the distances between operating locations and the rendezvous point, as well as planning time required for different takeoffs, planning a strike package from more than a couple locations would be risky.

More importantly, the cost/exchange ratio seems to heavily favor China in the exchange between missile strikes and air base protection. Redeploying existing PLARF brigades, changing targeting strategies, or even building more missiles is seemingly cheaper than the kind of investments the United States and Japan would have to make to preposition equipment, improve infrastructure and logistical support, expand runway repair training, and put in place robust missile defenses to counter the Chinese missile threat.

IMAGE 6. DF-16 Ballistic Missile as Seen After a Military Parade in Beijing, September 3, 2015.

Source: IceUnshattered, CC BY-SA 4.0 https://creativecommons.org/licenses/by-sa/4.0, via Wikimedia Commons, September 3, 2015, https://commons.wikimedia.org/wiki/File:Dongfeng-16.JPG.

China also has another key advantage over the United States and Japan: operational simplicity. Simplicity is a principle of war, and there is a good reason for it.[120] As the Prussian military theorist Carl von Clausewitz famously observed, "Everything in war is very simple, but the simplest thing is difficult."[121] PLARF brigades would operate on the mainland, moving across the country on its network of roads and railways. In contrast, the United States would operate from dispersed locations across the Japanese and Mariana Islands archipelagos, where the water between these many islands would impede movement of ground crews and their equipment without the support of transport aircraft and ships. The logistics and sustainment requirements would be staggering in scale, and the planning and execution of these operations would be inherently complex—even before the PLA attempted to disrupt or contest these movements, making it a whole lot worse.[122]

Photo by Staff Sgt. Daryn Murphy

Policy Recommendations

To counter the threat to U.S. air bases in the Pacific, the United States will need to outthink—not outspend—China. Doing so requires developing doctrine and capabilities that can mitigate the impact of Chinese missile attacks on air bases and airfields in the region. The pursuit of technological "silver bullets"—to reestablish U.S. air bases as sanctuaries from enemy attacks—will remain elusive. Many analysts in the U.S. Air Force and the defense industry seem to believe that some combination of a dispersed force posture and massive investments in game-changing technology would allow the United States to continue to employ air-superiority fighters, operating from relatively long runways, so it could seize and maintain air control within the First Island Chain. But these analysts seem to forget the critical enabling role of tankers: those short-legged fighters cannot cover the distance to most targets in the Taiwan Strait or patrol the airspace for long over the South and East China Seas without tanker refueling operations. And, because denying tanker operations requires fewer runway cuts, Chinese missiles could shut them down even longer than it could shut down fighters and still achieve the same effect of suppressing U.S. airpower in the critical first days and weeks of a war.

Instead of trying to restore the Gulf War paradigm—in which forces first seize air superiority and only conduct other aerial missions thereafter—the Air Force should embrace new operational concepts and capabilities for employing airpower early in a war, concepts and capabilities that rely upon on support from allies and partners and implement a strategy of air denial early in a war.[123]

Make Allies and Partners First-Line Air Defenders

U.S. airpower has often served as a frontline rescue mechanism, coming to the immediate aid of allies and partners in times of crises and armed conflict. Airpower has long been well suited to this role because warplanes can arrive rapidly to shore up allied and partner defenses and blunt enemy attacks. Put differently, American airpower has underwritten extended deterrence—with its promise that it can deny an adversary from achieving a fait accompli and buy time for a large number of U.S. reinforcements to arrive in the theater.[124] This concept of "buying time" still makes good strategic sense, as large numbers of forward-deployed forces would be expensive, encourage free-riding by allies and partners, and exacerbate the security dilemma with China, outweighing the potential deterrence benefits. These forces would also likely end up concentrated at large bases in the region, leaving them vulnerable to an adversary's first strike. Thus, the costs and risks of massing U.S. forward forces across Japan, Guam, and other Pacific islands probably outweigh the potential deterrence benefits and, counterintuitively, threaten to undermine regional security and stability by creating tempting targets for a devastating first strike by China. Clearly, Washington needs to find a different way to buy time in the initial stages of a possible conflict.

> ***The cornerstone of a new approach should be allies and partners armed and capable of fighting a tough delaying action without requiring the immediate support of massive amounts of American airpower at the outset of hostilities.***

Given that China will always have the quantitative advantage over its neighbors, U.S. allies like Japan and the Philippines, as well as partners like Taiwan, should invest in asymmetric capabilities—including large numbers of relatively inexpensive, runway-independent drones, electronic warfare systems, mobile ground-based air defense systems, and air-to-air and air-to-surface missiles—to convince Beijing that its forces would not be able to quickly obtain the air superiority required to mount successful offensive operations. Allied and partner air strategies should be oriented toward the goal of achieving air denial—in which their air forces aim to deny operational freedom to the PLAAF without necessarily being able to control that airspace themselves.[125] As Maximilian K. Bremer and Kelly A. Grieco have proposed, a volumetric defense—which layers the effects of air-based air defenses, ground-based air defenses, cyber disruptions, and electromagnetic jamming in increasing degrees of strength, both vertically and horizontally—is required to implement this strategy. In this concept, the outer layers consist of a mix of sensors, platforms with air-to-air missiles, cyber, electromagnetic capabilities, and ground-mobile long- and medium-range surface-to-air missiles to cover the medium- and high-altitude flight paths and approaches of fighters and bombers. The inner layer includes thousands of anti-aircraft guns, short-range and man-portable surface-to-air missiles, rockets, drones, and loitering munitions to deny control of the air littoral—that is, the airspace between surface forces and the altitudes where most traditional crewed aircraft typically operate.[126]

Although a strategy of air denial has been used successfully in past wars—most famously in the 1940 Battle of Britain —today the declining costs and increasing capabilities of these systems mean U.S. allies and partners not only have new and more effective ways to contest the airspace and blunt enemy attacks but might also be able to sustain those operations even through high losses. By building their air forces around massive numbers of drones and missiles of various types, allied and partner forces would acquire the combat-credible capabilities necessary to disrupt and delay Chinese offensive operations.

Specifically, saturating the airspace would create numerous difficult and time-consuming dilemmas for the PLA to solve before it could attain air superiority and, in the process, slow down and interfere with the timing and tempo of Chinese operations.[127] Because these capabilities are relatively low cost compared to traditional platforms, U.S. allies and partners could afford to acquire, lose, and replace them in large numbers.[128] The United States ought to fully leverage these developments to its advantage, shifting the main burden for contesting control of the air back to its allies and partners and instead assume a supporting role in this allied- and partner-led air-denial campaign at the beginning of hostilities.

The United States should support its allies and partners in acquiring robust air-denial capabilities, prioritizing the co-development and co-production of the drones and missiles that will be critical to their defense. Many allies and partners still prioritize prestige weapons systems, like Taiwan's recent purchase of more advanced F-16 fighters and Japan's plans to co-develop a sixth-generation fighter jet with the United Kingdom and Italy, which will be of limited utility early in a war.[129] Instead, Japan and Taiwan should focus on purchasing and investing in high-priority air-denial capabilities. Both countries will need to spend more on defense, increasing defense purchases and production as well as expanding basic and specialized training in drone warfare.

Reinvent the Inside Air Force

To ensure the United States can effectively support its allies and partners, the Air Force needs to embrace a new concept for an "inside air force." Chinese missile attacks could deny the use of air bases and airfields to U.S. fighters and bombers—and the aerial refuelers on which they depend for fuel—at the outset of a war. The United States could still fly bombers into the conflict area, but the long distances involved in operating them from bases in northern Australia, Hawaii, and Alaska would reduce the number of sorties flown each day. Simply put, the bulk of American airpower could be sidelined in the first days—and even weeks—of an armed conflict.

If the U.S. Air Force is to fulfill its promise of "airpower anytime, anywhere," the service will need to posture itself differently within the First Island Chain and develop new concepts for employing airpower in a highly contested environment, one that includes repeated missile attacks on air bases and airfields in the region. Accordingly, this inside air force should be built around runway-independent platforms of various types—including drones built to fly at different ranges—rather than traditional air-superiority fighters. Early in a war, the United States and allies would also want to position enough aircraft forward and incorporate deception—such as decoy fighters and inflatable aircraft hangers—to ensure runways act as "missile sponges," absorbing the PLARF's missile stocks.[130]

> ***This inside air force, acting in concert with allied and partner forces, should make air denial its primary mission.***

Air denial aligns with Indo-Pacific Command's Hellscape plan, which seeks to saturate air above and the waters on and below the Taiwan Strait with thousands of uncrewed systems should China attempt to take the island by force. "I want to turn the Taiwan Strait into an unmanned hellscape," Admiral Samuel Paparo, the top U.S. commander of the Indo-Pacific, has said, explaining, "So that I can make their lives utterly miserable for a month, which buys me time for the rest of everything."[131] The United States would still employ "outside" bombers, or even cargo aircraft carrying palletized munitions, to help blunt Chinese attacks, but they are not a substitute for an inside air force.[132] Between standoff strikes, or what some call "pulsed operations," the U.S. Air Force still needs a way to keep the Chinese air force occupied and to divert its attention and resources away from supporting the main offensive effort.[133] The inside air force would fulfill that purpose.[134]

Over time, as standoff and close-in strikes destroy China's air defense destroyers, rolling back the reach of China's A2/AD capabilities, the United States could bring forward more traditional crewed aircraft—including advanced fighters and the tankers required to support them—and transition to air superiority and offensive strike missions. To make that happen, however, the U.S. Air Force will need to move more rapidly toward uncrewed and autonomous systems, preposition equipment and munition stockpiles, and prepare to prioritize air denial in the initial air war.

Prioritize Logistics and Sustainment

The ability to supply and sustain this inside air force is critical to effective deterrence. Given China's ability to deny the use of runways to U.S. cargo aircraft, the United States should prioritize prepositioning fuel, weapons, and equipment in Japan, Guam, and other Pacific locations. The United States could use ships to send these materials across the Pacific, but this option would increase the time it takes to resupply forces and would probably encounter disruptions from Chinese attacks on ports.

Instead, the United States should focus on building up its stockpiles of weapons, fuel, and other critical supplies—including RADR kits—to ensure it can remain in the fight. The location of those stockpiles will need to be hardened, buried, and dispersed. The U.S. should also invest more heavily in improving the access roads and infrastructure at civilian airfields in Guam, the Northern Mariana Islands, and the Pacific Freely Associated States.[135] In addition, Washington should consider coproducing fast-drying concrete with Japan because in-country production of the specialized material would make resupply much easier. The Indo-Pacific Command has acknowledged the need to close many of these shortfalls, but it still perennially underfunds them, with many relegated to its unfunded priorities list.[136] This is a strategic mistake.

> ***Effective deterrence depends on convincing Beijing that the United States can sustain air operations with sufficient mass in the face of attacks on its runways and supply lines.***

This will require substantial preconflict preparation and sustained investments in U.S. defense infrastructure across the region. Policymakers should be under no illusions about whether U.S. air bases will come under attack: They will, and the human and materiel costs will be high. American Airmen will face an operational environment more akin to what the Royal Air Force faced in the Battle of Britain—when the Luftwaffe attacked its airfields—than the operational safe havens that the United States enjoyed in the 1991 Gulf War and the Global War on Terror. American political and military leaders—as well as the American public—should ask themselves carefully when—and for which national security interests—the country should be prepared to pay the heavy price in lives and equipment.

Appendix A

The model used in this study includes five categories of input variables: 1) the number, location coordinates, and dimensions of runways and taxiways at U.S. military bases, Japan Self-Defense Force bases, and civilian airfields that meet military occupational specialty (MOS) requirements for fighter or tanker operations; 2) the location of PLARF brigades and the number, type, accuracy, and reliability of PLARF missiles available at each brigade for runway attacks; 3) the location, type, and effectiveness of U.S. and JSDF missile defense units and the number of interceptor missiles available; 4) the time it takes to repair a destroyed section of runway or taxiway; and 5) the quality of Chinese intelligence information. All input values were based on unclassified and open-source information.

First, the project team collected open-source data on runways and taxiways located in Japan, Guam, and the Northern Mariana Islands, and the Pacific Freely Associated States.[137] They categorized these runways and taxiways by use type—U.S. military, JSDF, or civilian. Joint-use airbases—shared by the U.S. military and JSDF—were coded as U.S. military, assuming the United States would be able to use them in wartime. Similarly, all joint-use airfields between civilians and the JSDF or U.S. military, such as Misawa Air Base/Misawa Airport, were coded as U.S. military or JSDF, on the assumption that the U.S. military or JSDF would have exclusive use of them in wartime. In addition, civilian airfields in Guam, the Northern Mariana Islands, and the Pacific Freely Associated States were included in the same dispersal tier as JSDF airfields because the United States has more reliable access to these locations.

In total, researchers identified 11 U.S. military bases with 17 runways, 25 JSDF air bases with 30 runways, four civilian airfields outside Japan with five runways, and 55 civilian airfields in Japan with 61 runways that meet the MOS for fighters and/or tankers (Figures 8-10). They also identified 80 taxiways and three usable decommissioned runways that meet the fighter MOS and load-carrying capacity for the launch and recovery of fighters. These taxiways could serve as auxiliary runways for fighter sortie generation, but they will wear out far faster because they are not constructed to the same standards as main runways. Moreover, taxiways are typically too narrow and lack the load-bearing capacity to support recurring use by heavier aircraft, like tankers and bombers.[138] Both U.S. military and JSDF officers also emphasized that generating fighter sorties from taxiways would require additional ground lighting and could also necessitate arresting gear for landing or a catapult for takeoff, but such equipment is currently unlikely to be in place.[139]

Second, the researchers determined the location of PLARF brigades; estimated the total number of PLARF launchers and missiles available to execute the runway-attack mission; and used open-source information to assess the range, payload, reliability, and accuracy of each missile type.[140] They relied on open-source reporting about the known locations of PLARF missile brigades and the type of systems they operate (Figure 1). The model calculated the distance between these brigade locations and runway targets to determine whether Chinese missiles were within range, adding 200 kilometers to open-source range estimates to account for road mobility.

As noted earlier, the latest Pentagon assessment reports the PLARF's ground-based conventional missile arsenal includes about 750 ballistic missile launchers with 2,500 missiles and 150 ground-based cruise missile launchers with 300 missiles.[141] Using these numbers as a starting point, the researchers estimated specific missile inventory totals (e.g., approximate number of DF-17 missiles vs. DF-21 missiles comprising its total of 1,000 MRBMs of all types). Though the number of Chinese missiles by specific type is not available in open source, the number of missile launchers by type is in the public domain.

Accordingly, a ratio of missiles per launcher was created to estimate the number of each missile type in China's inventory. For example, given that China is reported to have 1,000 SRBMS and 200 SRBM launchers, the analysis assumed that each type of SRBM launcher accounts for five missiles. The analysis accounts for two further reductions to China's total missile inventory available for the mission: First, the model excluded the DF-11 and DF-15 SRBMs deployed across from Taiwan, assuming Chinese military planners would hold back these missiles to strike targets in Taiwan. Second, it employed only ballistic and cruise missile types reported to have ground-penetration capabilities. For example, to account for anti-ship and nuclear variants, the analysis removed 200 DF-21 and 100 DF-26 missiles from the missile inventory available for runway attacks. This leaves a total of upwards of 765 launchers and 2,004 ballistic and cruise missiles (Table 9) available to the PLARF to execute repeated attacks on runways in the theater.

Third, the project team assessed U.S. military and JSDF missile defense capabilities to determine the location, type, effectiveness, and total number of launchers and interceptor missiles capable of intercepting cruise and/or ballistic missiles and available for air-base protection. As discussed earlier, U.S. missile defense capabilities are extremely limited in the Indo-Pacific beyond the four U.S. Army Patriot batteries based in Okinawa. Though the Army has two additional batteries deployed in South Korea, as well as a THAAD battery, given fears about a North Korean provocation, these batteries are likely to remain on the Peninsula. The U.S. Navy's Seventh Fleet, headquartered in Yokosuka, Japan, also has destroyers and cruisers equipped with Aegis missile defense systems, but in the event of a conflict, these ships would probably be tasked with protecting Yokosuka, escorting the carrier strike group, joining a surface action group or amphibious ready group, or defending USS Blue Ridge, a command-and-control ship and the flagship of the Seventh Fleet.

Accordingly, the model assigns three of the four U.S. Army Patriot batteries to protect air bases in Japan, assigning two batteries each to Kadena Air Base and one to Marine Corps Air Station Futenma. The fourth battery is held in reserve—assigned to other missions, such as protecting communications facilities or munitions storage sites, or provide backup air-base protection when other batteries require equipment maintenance or repairs. Given that the U.S. Army has about 1,200 interceptor missiles in its entire inventory, and assuming these missiles are evenly distributed across its 15 Patriot battalions, each Patriot battalion should have about 80 Patriot missiles—or 20 per battery. In a crisis, however, the United Stats would likely send more missiles to the U.S. Patriot batteries in Japan. To account for this reallocation, the model allocated four times as many missiles—240 missiles in total—to each of the three U.S. Patriot battery assigned to protect runways in Okinawa.

To protect Andersen Air Base in Guam, the United States was assumed to have one THAAD battery deployed on the island. With the entire U.S. inventory of THAAD interceptors estimated to be 500, and assuming these missiles were allocated evenly among the Army's seven batteries, each THAAD battery had approximately 71 missiles. Given the strategic importance of Andersen Air Base as a hub for U.S. bomber operations, the analysis increased the number allocated to Guam's THAAD battery by 40%, to 100 missiles.

In addition, U.S. ally Japan operates 28 PAC-3 or PAC-3 MSE Patriot fire units (or batteries) and eight Aegis-armed destroyers.[142] Researchers relied on defense program and budget documents published by Japan's Ministry of Defense to determine the number of Patriot missile interceptors (PAC-3) in

Japan's inventory, estimating a total inventory of approximately 500 PAC-3 interceptors.[143] For modeling purposes, these missiles were evenly distributed across Japan's 28 Patriot firing units; 17 missiles were allocated to each unit.

In the event of a conflict, however, Japan would be highly unlikely to dedicate all its missile defense units to the protection of air bases and airfields. As one senior JSDF officer explained, in addition to protecting other high-value military targets, such as command-and-control facilities, key government buildings, supply depots, and ports, Japan would also prioritize deploying Patriot units to protect its cities, civilian population, and operable nuclear reactors from missile attacks.[144] Accordingly, the model assigns only half of Japan's Patriot units to air-base protection, prioritizing JASDF bases operating fighter squadrons and distributing them evenly to bases across the country.[145] It also assumes that Japan would provide missile defense capabilities to Misawa Air Base and Yokota Air Base—both of which are shared by the JSDF and U.S. Air Force.

For both U.S. Army and JSDF missile defense operations, the model used single-shot probability of kill (SSPKs) of 60 %—for both the Patriot and THAAD systems.[146] The effectiveness of missile defense interceptors is difficult to predict with accuracy.[147] Test reports suggest a SSPK as high as 0.8 to 0.85, but these tests took place in a highly controlled testing environment.[148] As Jonathan McDowell, an astrophysicist at the Harvard-Smithsonian Center for Astrophysics, put it: "Things that work well at home on the test range don't always go as smoothly when deployed."[149] The Patriot systems can also intercept cruise missiles but they are harder to detect with their low-altitude flight profile. Accordingly, the analysis tested a range of interception rates, including those consistent with other open-source models.[150]

Fourth, the analysis estimated the time it takes to repair a destroyed section of runway. As noted earlier, a 93-person, small repair team has the tools, equipment, and vehicles to repair 18 small craters (8.5 ft x 8.5 ft x 2 ft) or two large craters (30 ft x 30 ft x 2 ft) in about 6.5 hours, plus the time required to conduct airfield damage assessments and mitigate explosive hazards. Accordingly, analysts estimated an eight-hour U.S. repair times for a single runway cut to account for explosive ordnance disposal.[151] For modeling purposes, the model also assumed that all trained personnel, operating equipment, and repair materials would be available and ready for use at U.S. air bases. For Japanese air bases, it estimates a runway repair time of 24 hours. The research team arrived at this number based on interviews with senior JASDF officers, who emphasized that while Japan had recently purchased rapid-runway repair kits with fast-drying concrete, it currently has insufficient numbers of engineers and repair crews to cover all its bases.[152] For civilian airfields, the model estimated a repair time of three weeks because researchers could not find any public evidence that either the United States or Japan has prepositioned RADR kits at these locations.

Finally, the model assumed the Chinese have perfect intelligence and battle damage assessments, so that they only have to re-attack repaired runway sections.[153] Without BDA information, China would have little recourse but to blindly re-strike all runway aimpoints based on its estimates of how long it would take to repair an MOS. It also assumed that China has sufficient intelligence to identify the approximate locations of Patriot and THAAD batteries and therefore the air bases and airfields likely to have missile defense coverage.

Appendix B

How many missiles are required for China to achieve at least a 90% chance of destroying all aimpoints at an air base or airfield? To answer this question, the analysts first determined the number of cuts the PLARF must make along the length of the surface to ensure that no undamaged portion of runway or taxiway is longer than the 5,000 or 7,000 feet required for fighters and tankers, respectively, to take off and land. Each cut also requires creating sufficient damage across the width of the runway so that no 50- or 147-foot section meets the minimum width-operating surface for fighters or tankers.[154] The analysis then used a Monte Carlo simulation to estimate the number of missiles required to achieve over a 90% chance of destroying all the aimpoints and thereby closing all the runways at a given air base or airfield. [155] This calculation depends on the width of the runway and the size of the MOS, the reliability and accuracy of missiles and the effectiveness of missile defense, as well as the number and dispersal radius of submunitions released by missiles that reach their targets.

Submunitions are smaller weapons contained within a larger missile warhead, which are ejected from the larger missile as it approaches an aimpoint and then penetrate the concrete before detonating, cratering runway and taxiway surfaces. There is very limited information in the public domain about Chinese warheads and the technical characteristics of their submunitions beyond that China has developed ballistic and cruise missiles with modular warheads or variants able to carry submunitions and high-explosive payloads.[156] For purposes of the Monte Carlo simulation, it is assumed that China uses a submunition that is similar in weight and impact radius to France's BAP-100 anti-runway bomb, used to attack runways in Chad in 1986 and in Iraq in 1991. The BAP-100 submunition weighs 32.5 kg (71.7-lb), including 3.5- kilograms (7.7-lb) of high explosives that detonate after penetrating the runway. The BAP-100 can facture the surface or create an upheaval zone with a 1.5-meter (or five-foot) radius in a runway or taxiway.[157] This information is used to calculate the number of submunitions each type of PLARF warhead could carry and then used Monte Carlo simulations to estimate the number of missiles required to ensure the submunitions disperse sufficiently to cover the width of the runways and taxiways.

The Monte Carlo simulation relies on the following assumptions and inputs:

- A minimum of at least two ballistic or cruise missiles target each aimpoint.
- The reliability of each runway-penetrating ballistic and cruise missile is 95%.
- The circular error probable and payload of each ballistic and cruise missile is based on values reported in open source (Table 9).[158]
- China uses conventional land-attack variants of its ballistic and cruise missiles armed with runway-penetrating submunitions. (The DF-11 and DF-15 SRBMs are not included in the simulation on the assumption that China reserved them for use against Taiwan).
- Chinese submunitions are similar in weight and impact radius to the French BAP-100 anti-runway bomb, resulting in an average 1.5-meter-radius (or five-foot) crater in the runway.

- The submunition reliability is 100%, given even unexploded submunitions require clearing, a process that may require the detonation of the unexploded explosive ordnance, to re-open the runway.[159] As a robustness check tested a submunition reliability rate of 95%.

- For air bases and airfields with missile defense capabilities, single-shot interception rates are assumed to be 60 %, with robustness checks conducted at 40 and 80%. For runways and airfields without the protection of missile defense, the interception rate is zero.

- To close an air base or airfield to air operations, Chinese missiles must have at least a 90% chance of destroying all the aimpoints at an air base or airfield—meaning they cause sufficient damage to deny the minimum MOS length and width requirements on all runways and taxiways.

TABLE 9. PLARF Missile Capabilities

Missile Name	Missile Class	# of Missiles	Range (km)	CEP (m)	Payload (kg)
DF-16	SRBM	315	1,000	5	1,000
DF-17	MRBM/HGV	700	2,500	5	1,000
DF-21C	MRBM	100	1,750	40	600
DF-26	IRBM	404	4,000	40	1,800
DF-10/DF-100	GLCM	300	2,000	5	500

The Monte Carlo simulation models a single missile shot, using a random draw to determine whether the missile successfully reaches its target, accounting for the missile's reliability and the effectiveness of missile defense, if present. If the missile landed, its impact point on a runway or taxiway was approximated by a normal distribution based on the CEP of the missile. For each submunition released by a missile, the model used a random draw, based on the submunition's reliability, to determine whether the submunition detonated on impact. If detonation was successful, the model then calculated where the submunition would land within a circle with a radius of 60 meters (196.85 feet), assuming the submunitions dispersed in a uniform random pattern within the circle. The model then determined whether any section of surface was equal or greater than the MOS length and width requirements for aircraft takeoff and landings.

For each pairing of a missile type to a runway width, the Monte Carlo simulation runs 30 trials of 1,000 iterations. These trials need to reach at least a 90% probability of successfully closing the air base or airfield. If they fail to meet this threshold, the above process repeats with an additional missile, iterating the number of missiles until that condition is met.

Endnotes

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84 Baseline assumptions include a 95% missile reliability, a CEP of 5m for the DF-16 and DF-17 as well as the DF-10 and DF-100, and a CEP of 40m for the DF-21C and DF-26, a 60% SSPK for missile defense interception, perfect Chinese battlefield damage assessment, and an eight-hour U.S. repair time for a single runway or taxiway cut.

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[138] The researchers used the Department of Defense's pavement rating analysis tool, known as Tri-Service Transportation Pavements-Transportation - Community of Practice ACN/ACR calculator, which is available at https://transportation.erdc.dren.mil/acnacr/, to determine if the identified runways and taxiways could bear the maximum load of U.S. fighter and/or tanker.

[139] Author Interviews with current and former senior JASDF officers and current and former U.S. Air Force officers between December 2023 and October 2024.

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[141] Department of Defense, "Military and Security Developments Involving the People's Republic of China 2023," 67.

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[144] Interview senior officer in Japan Ground Self Defense Force in December 2023. See also Ryo Nemoto, "Japan to update homegrown missile for nuclear plant, island defense," *Nikkei News*, March 4, 2023, https://asia.nikkei.com/Politics/Defense/Japan-to-update-homegrown-missile-for-nuclear-plant-island-defense.

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