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Key Points

In a large-scale conflict with the People's Republic of China (PRC), U.S. Air Force air bases in the Indo-Pacific will face sustained, complex, integrated attacks that include simultaneous strikes by ballistic missiles, cruise missiles, hypersonic weapons, and armed drones.

The capacity and accuracy of adversary long-range strikes have altered combat paradigms and threaten to drive U.S. combat aircraft to rear-area bases that are at less risk of attack but too distant from the operational battlespace to enable combat-relevant operations.

If the U.S. military is unable to generate operationally relevant combat air power from inadequately defended forward air bases, adversaries may perceive an opportunity to achieve consequential objectives without the deterrent of a timely U.S. military response.

A combination of integrated active and passive defensive measures will allow the Air Force to sustain effective combat sortie generation rates while under enemy fire. The current capabilities and capacities of both active and passive air defenses are inadequate to sufficiently protect U.S. air bases and other critical facilities on adversary target lists, especially in the Indo-Pacific.

Congress should direct that DOD clarify Title X roles and responsibilities for fielding ground-based active missile defenses to ensure the Air Force can generate the required combat sorties while under attack.

Congress and DOD should allocate resources to enable the Air Force to implement ACE and deploy capabilities to rapidly reconstitute air base operations after attacks. New funding and personnel allocations must accompany any new air base defense mission assigned to the Air Force.

Fighting the Air Base: Ensuring Decisive Combat Sortie Generation Under Enemy Fire

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Abstract

U.S. Air Force commanders must be prepared to fight their frontline air bases like any other weapon system. Their air bases must have the capacity to counter complex integrated air and missile strikes, rapidly reconstitute their operational capabilities when damaged, and continue to generate combat effects while under attack: these capabilities are critical to the success of future joint force operations.

Yet over the past 30 years, Air Force air base defenses, especially in the Western Pacific, have atrophied due to a lack of resources and funding. These deficiencies imperil the service's ability to provide joint commanders with force generation and striking options to secure U.S. interests and defeat aggression that threatens the international order. The Air Force and supporting military services must field cost-effective air and missile defense solutions to confound adversary targeting efforts and drive up attack costs against U.S. air bases in order to remain a relevant "inside force" capable of fighting alongside America's allies and partners. Air defense solutions should include a combination of dispersing forward operating forces, fielding effective active and passive air and missile defenses, and reconstituting air base operations after attacks to provide the necessary air base resilience. Effective active and passive defenses for the dispersed forces are also required. Active defenses include modular, layered kinetic and non-kinetic systems, including airborne systems, to counter inbound missile and drone threats. Passive defenses include early warning and threat tracking, significant hardening of air base facilities, damage control, and reconstitution capabilities, including substantial runway repair at each dispersed air base.

To date, neither Congress nor the Department of Defense (DOD) have adequately funded air base defense requirements. Without an immediate reversal of this trend, the Air Force may be unable to generate operationally relevant combat airpower in a near peer conflict, which would likely have devastating impacts on joint and combined campaigns. Inadequate air base defense also strains alliances, incentivizes potential aggressors, and may ultimately result in a strategic loss that has existential consequences for the United States and its allies.

"The increasing vulnerability of the present basing posture could cause the U.S. Air Force to lose a war. No matter what the number and quality of aircraft, extent of preparations, sufficiency of logistics, brilliance of commanders, or skill and courage of its people, if the Air Force cannot mount sufficient mission-capable sorties, it cannot fulfill its responsibilities in war."

-U.S. Air Force Scientific Advisory Board
Report of the Ad Hoc Committee on Airbase Performance, November 1987

Introduction

As the U.S. Air Force emerges from decades-long wars in Southwest Asia and turns its attention to strategic competition and potential conflict with the People's Republic of China (PRC), the Air Force must address its long-neglected requirement for air base defense. China's People's Liberation Army (PLA) has developed substantial reconnaissance and long-range strike capabilities that can potentially win an air war without engaging in an air-to-air battle. The PLA "wins without fighting" in the air by striking U.S. runways, taking out air base fuel and ammunition stores, and destroying Air Force aircraft on the ground before they can take off. From persistent overhead reconnaissance and hypersonic missiles to swarming drones guided by artificial intelligence (AI), expanding PLA capabilities have altered the character of threats to U.S. air bases. The Air Force is facing many of the same air base defense challenges it faced late in the Cold War, yet it is unprepared and ill-equipped to counter many of those same threats to its air bases today.

The premise of this paper is simple: the U.S. military faces a significant "threat to mission" if the Air Force and its joint force partners cannot adequately defend forward air bases in the Indo-Pacific or Europe against growing attack threats from potential adversaries like China and Russia. If adversaries effectively suppress U.S. airpower, the joint force will likely be unable to achieve its operational or strategic objectives in a near-peer conflict. Effective air base defense supports three operational objectives, especially in a large-scale, force-on-force conflict: **1) Effective combat sortie generation; 2) Force preservation;** and **3) Imposition of costs on adversary attacks.** Realizing these three air base defense objectives puts the U.S. military in the best position to deter would-be adversaries from pursuing hostile action and, if necessary, to fight and win in a conflict.

Secretary of the Air Force Frank Kendall acknowledges the criticality of the service's forward bases and the need to counter and operate through adversary attacks in Operational Imperative 5 (OI-5):

> *Department of the Air Force (DAF) Operational Imperative 5, Resilient Forward Basing: The [DAF] will complicate the adversary's plans to target its bases by distributing operations to dispersed locations and improving its ability to sustain and conduct continuing operations—all while selectively hardening base infrastructure against attack and invoking a combination of concealment, deception, and defenses.*[1]

In 2024, Air Force Chief of Staff Gen David W. Allvin added in testimony before a Senate subcommittee, "We are also committed to building forward basing resilient enough to enable continued sortie generation, even while under attack."[2] Allvin recognizes that air base

defense, to be truly effective in deterrence and shaping adversary decision-making, is not just about protecting forces but **retaining the Air Force's critical ability to project power at the forward edge of the battlespace**.

This paper explores the necessity for air base defense from both historical and threat-based perspectives. In a future conflict, the United States must fight alongside its allies and partners as an inside force to succeed against adversaries that enjoy substantial advantages in terms of time, space, and superior combat mass due to their proximity to the battlespace. Today's Air Force finds itself in the same position it was in at the end of the Vietnam conflict—with significant deficiencies in air base defense due to decades of underinvestment borne out of DOD's focus on low-intensity conflict. From the early 2000s, as the U.S. military was fighting the Global War on Terrorism, adversaries fielded increasingly complex integrated threats to U.S. air bases and deployed forces in the Indo-Pacific and Europe. In particular, U.S. Indo-Pacific air bases now face significant threats from PLA long-range fires enabled by dense air, space, and maritime ISR capabilities. However, a realistic and nuanced assessment of these threats reveals that cost-effective front-line air base defense is possible. Necessary air base defenses include:

1. Dispersing Air Force combat aircraft and supporting forces to multiple operating locations as envisioned by the service's Agile Combat Employment (ACE) concept;
2. Fielding a diverse, layered arsenal of active defenses that includes kinetic and non-kinetic effectors to provide cost-effective protection against incoming attacks; and
3. Increasing air base passive defenses, including early warning, threat tracking, hardening, and substantial reconstitution capabilities, especially rapid runway repair.

A number of other initiatives that the Air Force and its joint partners should pursue as part of a comprehensive air base defense complex include:

- Continue to develop, codify, and implement the ACE concept;
- Establish and fund a dedicated air base defense program that includes an inter-service agreement on air base defense responsibilities and program funding;
- Build out substantial passive air base defenses, including rapid runway repair and air base reconstitution capabilities, as well as space and airborne early warning capabilities;
- Significantly increase investments in air defense sensor and C2 capabilities;
- Develop and deploy a diverse arsenal of integrated active defense capabilities for air base defense that includes cost-effective, short-range kinetic and non-kinetic capabilities in addition to airborne and ground-based long-range kinetic capabilities; and
- Pursue additional studies and modeling to refine requirements for air base defense.

An operational concept for air base defense built on the ACE concept with a balanced mix of passive and active defense capabilities can enable the Air Force to achieve combat-relevant sortie generation rates while air bases are under sustained attack. If the U.S. military is unable to generate operationally relevant combat air power from inadequately defended forward air bases, adversaries may perceive an opportunity to achieve consequential objectives without the deterrent of a timely U.S. military response. Beyond jeopardizing deterrence, adversaries may be able to achieve their operational objectives if they can suppress combat sortie generation from forward U.S. and allied air bases in a conflict.

The difference between active and passive air and missile defenses (AMD)

Active AMD are defensive actions taken to destroy, nullify, or reduce the effectiveness of air and missile threats against friendly forces and assets. These actions include the use of aircraft and air-to-air missiles, surface-to-air missiles (SAMs), anti-aircraft artillery (AAA), electronic attack including directed energy weapons, and sensors that directly support those weapons.

Passive AMD are measures other than active AMD that are taken to minimize the effectiveness of air and missile threats against friendly forces and assets. Passive AMD includes air and missile detection and warning, threat tracking, camouflage, concealment, deception, dispersion, hardening, and the use of protective construction. It also includes reconstitution capabilities such as rapid runway repair to return an air base to operational readiness.

Source: Joint Chiefs of Staff, *Countering Air and Missile Threats*, JP 3-01 (Washington, DC: Joint Chiefs of Staff, April 6, 2023), pp. I-6–I-8.

Strategic Imperatives for Air Base Defense

Win without fighting… by destroying the nests

Understanding an adversary's decision-making calculus reveals why an effective operational concept for U.S. air base defense is critical for deterrence, especially in the Western Pacific. Many in the West are seemingly convinced of a prevalent and persistent myth: that China seeks to avoid combat—to win without fighting, supposedly in the tradition of ancient Chinese military strategist Sun Tzu. This win without fighting strategy has become synonymous with achieving a *fait accompli* in which an enemy force, such as the U.S. military, concedes before hostilities commence because defeat is all but ensured. However, Sun Tzu's win without fighting edict in historical context is better interpreted as routing enemy soldiers before they have an opportunity to form ranks and fight back—to attack and destroy opposing forces pre-emptively, thereby winning without engaging the enemy in a reciprocal battle.[3] This concept is reflected in the words of Italian General Giulio Douhet, one of the first airpower strategists, who wrote in 1921 about the merits of attacking air bases: "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."[4] These historical truths have not been lost on the PLA.

PLA strategists recognized the value of this strategy in their analysis of Operation Focus (*Moked*), Israel's opening gambit in the 1967 Six-Day War. On the morning of June 5, 1967, 200 Israeli Air Force (IAF) fighters and bombers struck Egyptian, Syrian, and Jordanian runways and then proceeded to destroy unprotected aircraft at the airfields. By mid-day, the Arab coalition had lost most of its air force. The first day of IAF attacks destroyed over 400 aircraft on the ground.[5]

In the 1973 Yom Kippur War, an Arab coalition launched a surprise attack against Israel. This time, however, Egypt and Syria prepared their air bases for the anticipated IAF response. They constructed hardened shelters at their air bases, bases that were now well-defended with Soviet-purchased surface-to-air missiles and air defense artillery. Unable to overcome the active and passive air base defenses, even after hundreds of sorties, the IAF managed to destroy only 22 Arab coalition aircraft on the ground. The Israelis resorted to runway attacks. However, the IAF observed that, in some cases, their opponents were able to effect repairs and generate combat sorties less than an hour after a runway strike.[6] There are valuable lessons for both the PLA and the U.S. Air Force in these conflicts.

Back to the future—1985 to 2024

In the 1970s, the U.S. Air Force understood the implications of the Arab-Israeli air base battles. However, the Air Force experience in the Vietnam conflict overshadowed any lessons learned from the Middle East. North Vietnamese Army and Vietcong attacks against Air Force main operating bases in South Vietnam destroyed 94 and damaged over 1,100 aircraft. These attacks were not from enemy aircraft attacking air bases but came almost exclusively from rockets and mortars. In response, between 1968 and 1970, the Air Force constructed over 400 hardened aircraft shelters in Vietnam designed to defeat the most likely high-end threat—122-mm rocket attacks.[7] In 1969, the Air Force's program to rapidly construct concrete and steel "Wonder" shelters expanded to Europe and elsewhere in Asia. The shelters were a hedge against the possibility of attacks by special forces or irregular forces. In the aftermath of the Vietnam conflict, the U.S. Air Force was still not seriously considering the threat of Soviet long-range conventional strikes on U.S. air bases in Europe and Asia.[8]

By the early 1980s, however, the Soviets developed substantial power projection and precision strike capabilities that threatened to overwhelm Western European air base defenses. In response, the United States deployed new weapons like the Patriot surface-to-air missile system to enhance European air defenses.[9] At the same time, similar to the present-day Agile Combat Employment concept, the Air Force's Collocated Operating Base (COB) program dispersed its aircraft across dozens of allied airfields to diffuse potential Soviet strikes. The United States and its NATO partners also constructed shelters that were substantially more hardened than the Vietnam-era Wonder shelters to protect aircraft and personnel. Despite these initiatives, computer simulations still showed that strikes against U.S. Air Force bases in the first week of a Soviet attack would likely cut the service's aircraft sortie generation by 40 percent and destroy up to 40 percent of its deployed aircraft on the ground.

A multi-week air power exercise in the spring of 1985 named "Salty Demo" produced a realistic assessment of U.S. air base vulnerabilities.[10] The exercise simulated a Soviet strike on Spangdahlem Air Base, West Germany. Simulated attacks removed aircraft, buildings, and equipment from play. The notional damage took utilities and communications offline and assumed one-third of base personnel were killed or injured. Air Force combat engineers cratered the alternate runway at Spangdahlem with live explosives just so they could attempt repairs.

Salty Demo was, by one account, "a sobering demonstration of the synergistic chaos that ensues when everything goes wrong at the same time."[11] The Air Force addressed the Salty Demo findings by intensifying what it called its Air Base Operability (ABO) program, not just in Europe but worldwide. By 1988, Air Force leadership said the priority for base defense had progressed from "urgent" to "critical." Initiatives included increasing active defenses as well as passive defenses, such as camouflage, concealment, deception, and hardening of facilities. Damage control capabilities and rapid runway repair became priorities. Incidental to those initiatives, the Air Force and Army signed a memorandum of understanding in 1984, securing an Army commitment to provide ground-based air defenses for air bases.[12] Air Force leaders began talking about "fighting the air base," elevating their bases to the same level as their other operational weapon systems.[13]

The Air Force's late-1980s base defense efforts reflected an understanding of the threat and a concerted effort to address

shortfalls. And then, the Cold War ended. For the next thirty years, from the 1990s through 2020, the United States focused on regional conflicts in Southwest Asia and, to a lesser extent, the Balkans. For most of that time, the U.S. Air Force enjoyed air superiority by default. Its adversaries possessed nothing like the sophisticated precision strike complexes of the Soviet Union. The 1984 agreement that addressed Army responsibilities for providing ground-based air defense for Air Force bases expired unnoticed in the 1990s when neither service sought to renew the memorandum. The stresses from operations in both Afghanistan and Iraq in the 2000s also led the Army to cancel a separate agreement with the Air Force on air base perimeter defense, leaving Air Force security personnel to defend their bases against attacks by insurgents and terrorists.[14] Threats facing U.S. air bases in Southwest Asia were more akin to what the Air Force had experienced in Vietnam. Airmen were on alert against ground incursions or rocket and mortar attacks, as well as the more recent threat of small, remote-control drones.

In the 2010s, the U.S. military had become so distracted by the post 9/11 counterinsurgency fights that it was slow to recognize the renewed threat to its forward air bases as Russia and a rapidly modernizing China developed new generations of long-range precision strike weapons. In 2004, Pacific Air Forces (PACAF) did begin to recognize the growing PRC threat and advocated for building hardened shelters at Anderson Air Force base on Guam to protect the B-2s and F-22s required for the Global Strike Task Force (GSTF), a concept specifically designed to defeat growing PRC threat capabilities.[15] The cost of the proposed shelters was approximately $1.8 billion, with an estimated completion date of 2008. The Air Force summarily canceled the proposal due to a lack of funding.

Coming full circle, in 2023, the DAF's OI-5, *Resilient Forward Basing*, recognized that the Air Force has many of the same base defense requirements it faced in Western Europe in 1985. The Air Force repackaged the Cold War-era Air Base Operability program as ACE, a concept to spread aircraft operations across established and dispersed airfields. ACE, like ABO, necessitates more active air and missile defenses, requiring the Air Force to once again come to some agreement with the Army on their shared responsibility for air base defense. More than anything, the Air Force's leadership and personnel must once again think in terms of "fighting the air base."

Requirement to remain an inside force

The U.S. Air Force must be able to generate combat sorties under hostile fire from established and dispersed forward air bases alongside allies and partners. Fighting forward with a coalition of like-minded nations is a cornerstone of U.S. alliance agreements and regional military strategies. More importantly, operating alongside allies and partners within range of adversary anti-access/area denial (A2/AD) capabilities serves key operational and strategic objectives.

On an operational level, the Air Force's ability to deliver combat effects as an inside force will depend on defeating threats to forward air bases. Conversely, effective air base defense supports three operational objectives, especially in a large-scale, force-on-force conflict with a near-peer adversary:

1. **Effective combat sortie generation:** Defending forward bases and operating from those bases is the only practical way to generate required airstrikes and deliver other combat relevant effects given a lack of sufficient long-range, stand-off capabilities.

2. **Force preservation:** Robust active and passive air base defenses must mitigate the significant threat of damage to critical infrastructure and aircraft attrition. Valuable combat aircraft, support aircraft, personnel, maintenance facilities, and fuel may be difficult, if impossible, to replace, especially during a weeks- or months-long crisis.
3. **Adversary cost imposition:** An adversary must expend scarce and expensive weapons in return for minimal operational effects *if* the Air Force and its partners execute effective air base defense.

Realizing these three air base defense objectives will serve to deter would-be adversaries from pursuing hostile action. Air base defense is a core capability in a "peace-through-strength" deterrence strategy.

Without effective forward air base defense, the math in a near-peer adversary conflict does not favor the United States and its allies. The current U.S. bomber force lacks sufficient capacity to conduct the number of strikes necessary across large areas in countries like Russia and China. This shortfall will likely persist at least through the 2030s.[16] For all intents and purposes, U.S. allies and partners do not possess

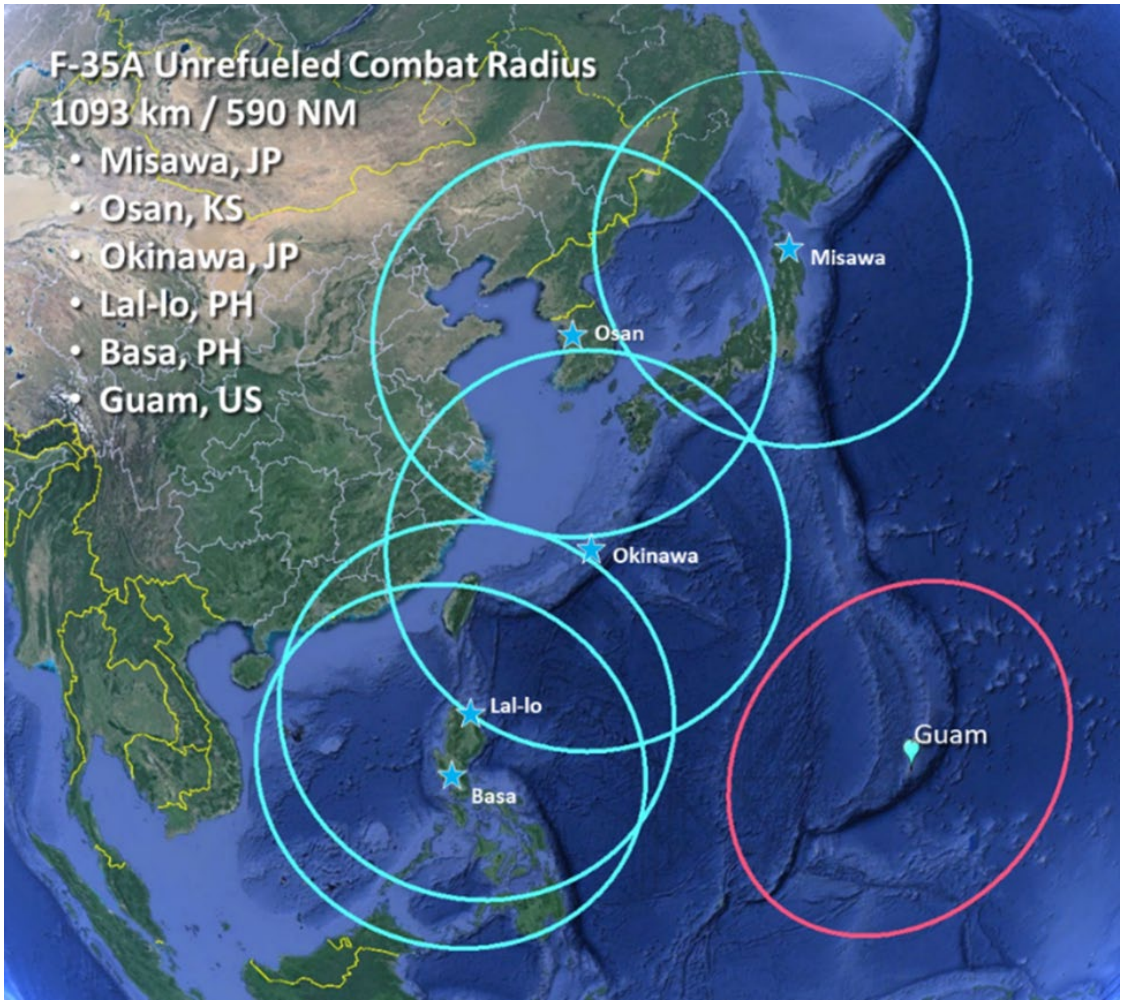

Figure 1: This diagram shows the unrefueled combat radius of an Air Force F-35A fighter from Pacific theater bases, illustrating the challenge of operating these fighters from distant air bases like Guam.

Source: Mitchell Institute based on data from Lockheed Martin, "F-35 Lightning II Program Status and Fast Facts," April 1, 2020

extremely long-range (i.e., global) capabilities to conduct strikes from outside A2/AD areas.

The Air Force does have sufficient strike-fighter aircraft and weapons to conduct widespread operations. These aircraft may be able to fly initial combat sorties from far-flung bases, relying on tankers to transit to an area of combat operations. However, significant transit distances—especially in the Indo-Pacific—as well as airborne tanker availability make this approach unsustainable. Even with sufficient fuel from vulnerable and difficult-to-defend tanker aircraft, strike-fighters operating from Guam or Northern Australia *might* be able to generate a single long-range combat sortie each day. Meanwhile, crewed and uncrewed combat aircraft operating from forward bases along the First Island Chain may be able to generate three times as many sorties to conduct strikes on high-value adversary targets. It is virtually impossible to generate the sortie rates and mass needed to prevail in a large-scale conflict in East Asia only operating from air bases located thousands of miles from the battlespace. Instead, Air Force combat forces must deliver effects from air bases that are inside adversary A2/AD envelopes and relatively close to potential areas of combat operations.

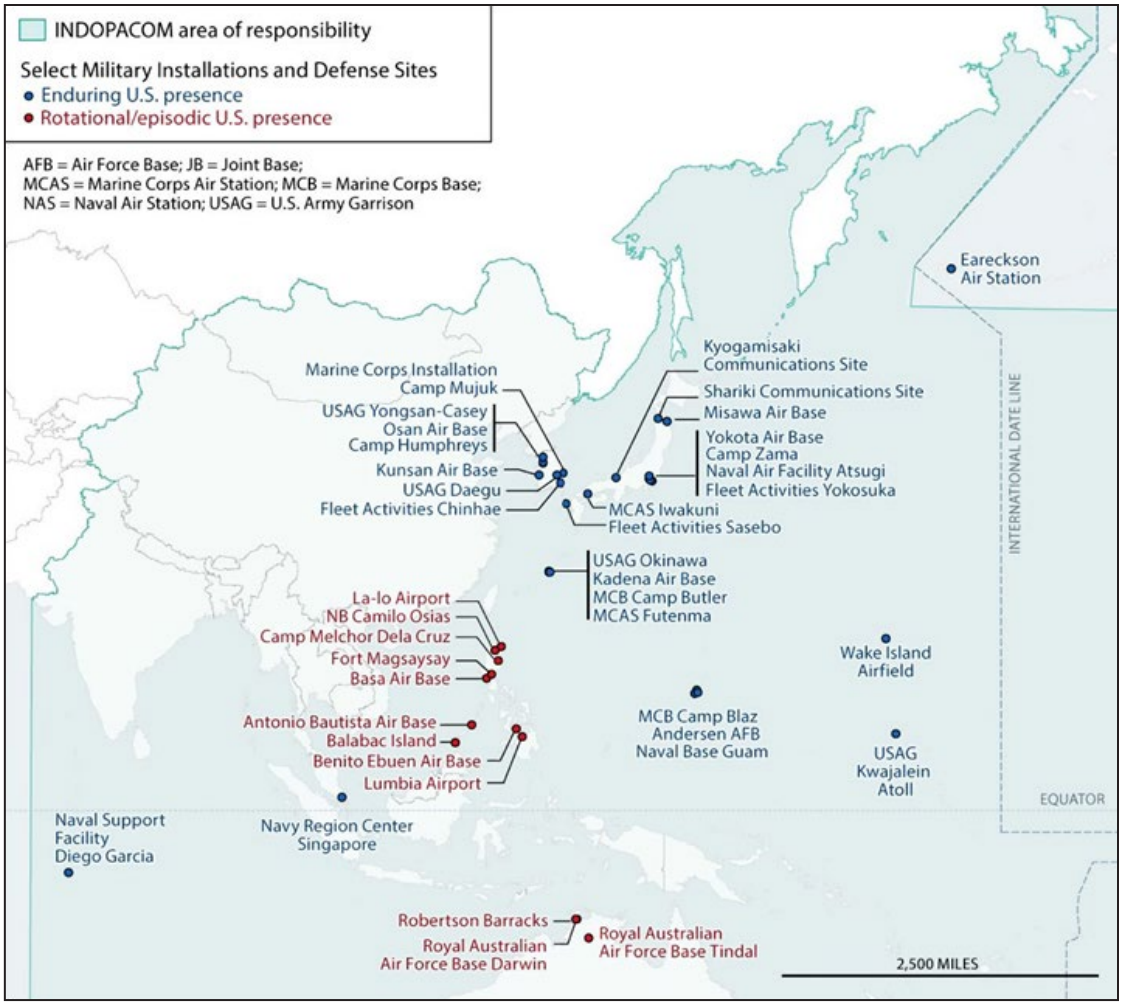

Figure 2: U.S. Defense sites west of the International Date Line. This map shows that most U.S. air bases and other military facilities in the western half of the INDOPACOM area of responsibility (AOR) are located on the Korean Peninsula and along the First Island Chain, extending from Northern Japan to the Philippines.

Source: *U.S. Defense Infrastructure in the Indo-Pacific: Background and Issues for Congress*, CRS Report No. R47589 (Washington, DC: Congressional Research Service, 2023), p.13.

Russian Threats to U.S. and Allied Air Bases in Europe

NATO certainly should not discount the threat of Russian military strikes against European air bases. Russian forces cratered runways and inflicted significant damage on Ukrainian air bases in the opening days of Russia's 2022 invasion. However, two years into the conflict, the Russian Aerospace Forces (VKS) have been unable to achieve air superiority over Ukraine. The VKS appear to have abandoned an organized campaign for air superiority in favor of seemingly indiscriminate long-range strikes with ballistic and cruise missiles of questionable precision complemented by a large number of foreign-made *kamikaze* drones. To date, the VKS has vastly underperformed in the Ukraine conflict. Russia's long-range strike capabilities may take years to reconstitute. In light of these limits on Russian power projection, this paper focuses on the PRC, which is identified as DOD's pacing threat.

Strategically, the demonstrated capability and intent of the U.S. military to fight as an inside force reassures allies and partners. Most allied nations' proximities to regional threats do not allow them to retreat from a fight. While the United States successfully stood with Israeli forces against Iranian aggression in April 2024, many allies and partners are scrutinizing the recent U.S. withdrawal from Afghanistan and somewhat intermittent, often conditional support for Ukraine against Russian aggression. A perceived commitment to operate forward from well-defended air bases will reassure allied military and political leadership as well as the general population. Whether an ally or partner chooses to engage in a conflict and how hard they decide to fight may come down to perceptions of U.S. resolve, reflected in measures like investments in U.S. air base defense.

In Europe, the U.S. Air Force stood by America's NATO allies for over 75 years, flying forward from European air bases against terrorist threats and deterring the Soviet Union and now Russia. In the Pacific, it demonstrates capability and intent by operating with treaty allies like Japan, the Republic of Korea, and the Philippines while standing with emerging partners such as Vietnam. Time-tested relationships will surely fail if it becomes clear that U.S. allies and partners must resist aggression and fight alone while the United States withdraws to rear areas. In the absence of well-defended air bases, both friends and adversaries will question U.S. commitment to core principles of the established international order.

The U.S. Pacific Air Force's *PACAF Strategy 2030* identifies reinforcing allies and partners as one of its three strategic priorities. Current force structure and basing simply do not allow for a "go-it-alone" strategy; the Air Force and joint force must fight as an allied team. *PACAF Strategy 2030* also delineates requirements to continue to operate forward in the Indo-Pacific, advancing theater posture to expand access, basing, and overflight (ABO) for distributed air operations from new strategic locations.[17] Whether in the European, Central, or Indo-Pacific Commands, access, basing, and overflight from U.S. allies and partners will only be ensured if partner nations believe the U.S. military will stand with them.

Fighting forward as an inside force is also a necessary condition for achieving integrated deterrence against regional aggression and threats to U.S. interests globally. U.S. resolve to stand by allies and partners with a demonstrated ability to generate combat airpower inside adversary A2/AD engagement envelopes is key to stymieing the ambitions of challengers like China and Russia. These adversaries are developing long-range precision strike complexes that threaten to prevent the Air Force from operating its forces from air bases located along the Pacific's First Island Chain and in Europe. These strike capabilities serve an underlying objective of driving the Air Force from forward areas and separating the United States from its allies. The ability to base combat air forces alongside U.S. allies and partners within immediate striking distance

of adversary centers of gravity will conversely cause would-be aggressors to question the viability of their military plans.

Complex, Integrated Threats

Adversary capabilities and concepts for air base attacks should frame a discussion on capabilities and operational concepts needed for U.S. air base defense. The U.S. *National Defense Strategy* identifies the PRC as the Department's most comprehensive and serious challenge to U.S. national security. Unsurprisingly, that assessment translates to the PRC as the greatest military threat to air bases in terms of a future conflict. Importantly, the PLA has developed the command and control (C2) and intelligence, surveillance, and reconnaissance (ISR) capabilities necessary to enable its large and growing arsenal of long-range precision strike weapons to strike high-value U.S. targets, to include critical nodes in U.S. kill chains and capabilities crucial to generating combat sorties from theater air bases. In a large-scale conflict with the PRC, the Air Force should expect its air bases to face sustained, complex, integrated attacks that include simultaneous strikes by ballistic missiles, cruise missiles, and drones.

The threat from the PLA's large and growing arsenal of long-range precision strike weapons against air bases is serious, but not unsurmountable. There are practical, physical limits on the number of sophisticated weapons an adversary like the PLA may launch against dozens of established and dispersed air bases at any one time. A careful examination of available threat information indicates that layered, active defenses can effectively mitigate threats given the assessed salvo size of PLA ballistic missiles. The following analysis examines PLA strike capabilities in East Asia as the high-end threat to which air base defense requirements should be defined.

Adversary long-range strike & ISR capabilities

In a counter-intervention operation against U.S. military forces, PLA kinetic strikes would probably be effective as far as 1,500–2,000 nautical miles from the Chinese mainland—out to Guam, elsewhere along the Second Island Chain, and in the southern-most reaches of the South China Sea. Such strikes, if launched in sufficient volume without appropriate defenses, would seriously impede, if not stop, a U.S. military intervention in an East Asian conflict.[18] Additionally, as soon as the late 2020s, PLA surface ships and submarines may be able to operate within striking range of Alaska, Hawaii, and the U.S. West Coast, as well as Diego Garcia and northern Australia. These PLA naval forces could launch land-attack cruise missiles (LACM) or conventional ship-launched ballistic missiles against U.S. and allied bases, including air bases hosting bombers, tankers, and transport aircraft, on both sides of the Pacific and throughout the Indian Ocean.

The PLA enjoys significant advantages over the U.S. military in ISR coverage, especially along the First Island Chain. PLA ISR in East Asia is remarkably dense, featuring layered and overlapping coverage from diverse space-based and airborne collection capabilities, including electro-optic (EO), infra-red (IR), and hyperspectral imagery; synthetic aperture radar imagery; and different signals intelligence (SIGINT) capabilities. These technical collection capabilities complement PLA cyber and human intelligence (HUMINT), which may disclose the specific location of U.S. aircraft and equipment at air bases, as well as information on the launch and recovery of aircraft. Robust passive defensive capabilities that include significant camouflage, concealment, and deception (CCD) measures to counter these and other sensors that are integral to the PLA's long-range kill chains will be necessary to ensure U.S. and allied forces can operate from their forward air bases while under attack.[19]

Adversary synergies using salvos of diverse weapons

In a future conflict with the PRC, sustained, complex, integrated attacks designed to overwhelm existing active and passive defenses threaten U.S. air bases. Such attacks will feature different types of weapons launched in synchronized attacks that are notoriously difficult to defeat. Attacks on U.S. air bases will include a large number of relatively low-cost weapons like cruise missiles and drones combined with more expensive ballistic and hypersonic missile threats. Ballistic missiles attacking from high altitude at hypersonic speeds may maneuver in the terminal stage of flight. Hypersonic glide vehicles also ingress at high speeds and depressed angle flight paths that decrease a defender's warning times. Cruise missiles may approach at supersonic or sub-sonic speeds, often at very low altitudes, which also reduces early detection and warning times.[20] PLA drones include low-slow propeller-driven *kamikaze* drones as well as modified third-generation fighter aircraft that can drop bombs like an uncrewed combat aerial vehicle (UCAV) and then crash into a target with explosives onboard.[21] Tracking and engaging multiple, dissimilar air and missile threats arriving simultaneously from different directions at different altitudes and different speeds is a significant challenge for even the most sophisticated network of air defense sensors, command and control systems, and air defense effectors.

Table 1 provides context to understand the capabilities and limitations of the PLA's long-range strike capabilities.[22] Some conventional assessments of PLA capabilities tend to exaggerate the realistic striking range of these weapons. For instance, graphics

Table 1: Select PLA ballistic missile, cruise missile, and drone threats. Grayed out weapons lack range to effectively target bases in the First Island Chain. (cont. next page)

Missile Name	Type	Number of Launchers 2022	2028	Warhead	Max Range	3/4 Max Range
DF-11 (CSS-7)	SRBM	54-72	27-36	500 kg (1,100 lbs)	600 km (324 NMI)	450 km (243 NMI)
DF-15 (CSS-6)	SRBM	54-72	27-36	500 kg (1,100 lbs)	900 km (486 NMI)	675 km (365 NMI)
DF-16 (CSS-11)	SRBM	54-72	54-72	1,000 kg (2,200 lbs)	1000 km (540 NMI)	750 km (405 NMI)
DF-17 (CSS-22)	MRBM (HGV)	27-36	108-144	UNK	2,000 km (1,080 NMI)	**1,500 km (810 NMI)**
DF-21A (CSS-5)	MRBM	12	0	600 kg (1,300 lbs)	2,150 km (1,160 NMI)	**1,600 km (864 NMI)**
DF-21D (CSS-5 Mod 5)	ASBM	48	48	600 kg (1,300 lbs)	2,150 km (1,160 NMI)	1,600 km (864 NMI)
DF-26 (CSS-18)	IRBM/ ASBM	216	252	1,500 kg (3,300 lbs)	4,000 km (2,160 NMI)	**3,000 km (1,620 NMI)**
DF-10	GLCM	54-72 (Dual TEL)	54-72 (Dual TEL)	400 kg (882 lbs)	2,000 km (1,080 NMI)	**1,500 km (810 NMI)**
DF-100	GLCM	24 (Triple TEL)	24-48 (Triple TEL)	500 kg (1,100 lbs)	2,000 km (1,080 NMI)	**1,500 km (810 NMI)**

SRBM: Short-Range Ballistic Missile; MRBM: Medium-Range Ballistic Missile; HGV: Hypersonic Glide Vehicle; IRBM: Intermediate-Range Ballistic Missile; ASBM: Anti-Ship Ballistic Missile; GLCM: Ground-Launched Cruise Missile; ALCM: Air-Launched Cruise Missile, LACM: (Ship-launched) Land-Attack Cruise Missile; UCAV: Uncrewed Combat Aerial Vehicle.

Table 1 cont.: Select PLA ballistic missile, cruise missile, and drone threats. Grayed out weapons lack range to effectively target bases in the First Island Chain.

Missile/Drone Name	Type	Launch Platform	Warhead/ Payload	Max Range (one-way)	3/4 Max Range
ASN-301	GLCM loitering	Canister ground-launched	32 kg (70 lbs)	500 km (270 NMI)	375 km (202 NMI)
YJ-63	ALCM	Bomber	500kg (1,100 lbs)	200 km (108 NMI)	**150 km (81 NMI)**
AKF98A	ALCM (Like U.S. JASSM)	Fighter	UNK	UNK	**UNK**
AKF088C (TL-30)	ALCM loitering	Fighter / bomber	UNK	280 km (150 NMI)	**210 km (113 NMI)**
YJ-18B	LACM	Ship / submarine	150-300 kg (330-660 lbs)	540 km (292 NMI)	**405 km (219 NMI)**
CJ-10 / CJ-20	ALCM	Bomber	400 kg (882 lbs)	2,000 km (1,080 NMI)	**1,500 km (810 NMI)**
Q-5	UCAV (2nd Gen Fighter)	Air base	1,500 kg (3,300 lbs)	2,000 km (1,080 NMI)	**1,500 km (810 NMI)**
J-6	UCAV (2nd Gen Fighter)	Air base	500 kg (1,100 lbs)	1,690 km (912 NMI)	**1,268 km (685 NMI)**
J-7	UCAV (3rd Gen Fighter)	Air base	1,500 kg (3,300 lbs)	2,200 km (1,188 NMI)	1,650 km (891 NMI)
J-8	UCAV (3rd Gen Fighter)	Air base	4,500 kg (9,900 lbs)	2,200 km (1,188 NMI)	1,650 km (891 NMI)

often depict PLA strike capabilities in terms of maximum missile ranges radiating from the PRC coastline. Achieving such ranges would require missile transporter-erector-launchers (TELs) to drive far from their logistics bases to launch points on the coast. This would increase their vulnerability and threat of attack. Maximum-range shots may also reduce the reliability and accuracy of missile warheads. While such a tactic is certainly *possible*, it is not *likely*. The PLA would probably launch missiles within reasonable driving range of their bases at two-thirds or three-quarters of the demonstrated maximum range of the missile to increase the reliability and accuracy of the weapon. PLA short-range ballistic missiles (SRBMs) are optimized for strikes on Taiwan and cannot effectively range U.S. and allied air bases.

Realistic assessment of air base threats

Defense analysts often discuss inventories of ballistic missile threats in terms of hundreds of missiles. There seems to be a prevailing perception that those "hundreds of missiles" are available to attack a single category of targets—in this case, U.S. air bases. In any large-scale conflict with the United States in East Asia, the PLA will have dozens of priorities that are as high or higher than air bases on its target list. Countermeasures such as dispersing U.S. and allied air forces across multiple operating locations will challenge the PLA to cover the 2,000 nautical miles of the First Island Chain with effective ISR and then launch a sufficient volume of long-range strike weapons against air base targets.

Growth in the PLA's missile inventories is offset by the replacement of older missiles

like the DF-11, DF-15, and DF-21 with newer, more accurate, and longer-range systems like the DF-17 hypersonic glide vehicle (HGV) and the intermediate-range DF-26. In a Taiwan conflict, targets on Taiwan will likely be priorities for the PLA's SRBM replacement missiles like the DF-17, even though those missiles may have the range to target some U.S. and allied bases. Additionally, as the United States and its allies increase military capabilities in the region, PLA's missile inventory growth is further offset by growth in the PLA's presumed target list. While it is *possible* that most PLA long-range strike weapons would be allocated to U.S. air base suppression, it is more *likely* that the PLA will balance air base attacks with requirements to strike other high-value U.S. and allied targets, including theater air defenses; command, control, and communications; ISR capabilities; naval bases; ships; and logistics.

The number of PLA missile launchers is another limiting factor for how many missiles may be involved in any given air base attack. Moreover, *where* those launchers are located in the PRC, and the range of their respective missiles, limits the number of missiles available for an air base attack. That is, a missile launcher in northern China will not be instantly available to launch an attack from southern China. Figure 3 is a U.S. air base-centric depiction of potential PLA launch areas for air-launched or ground-

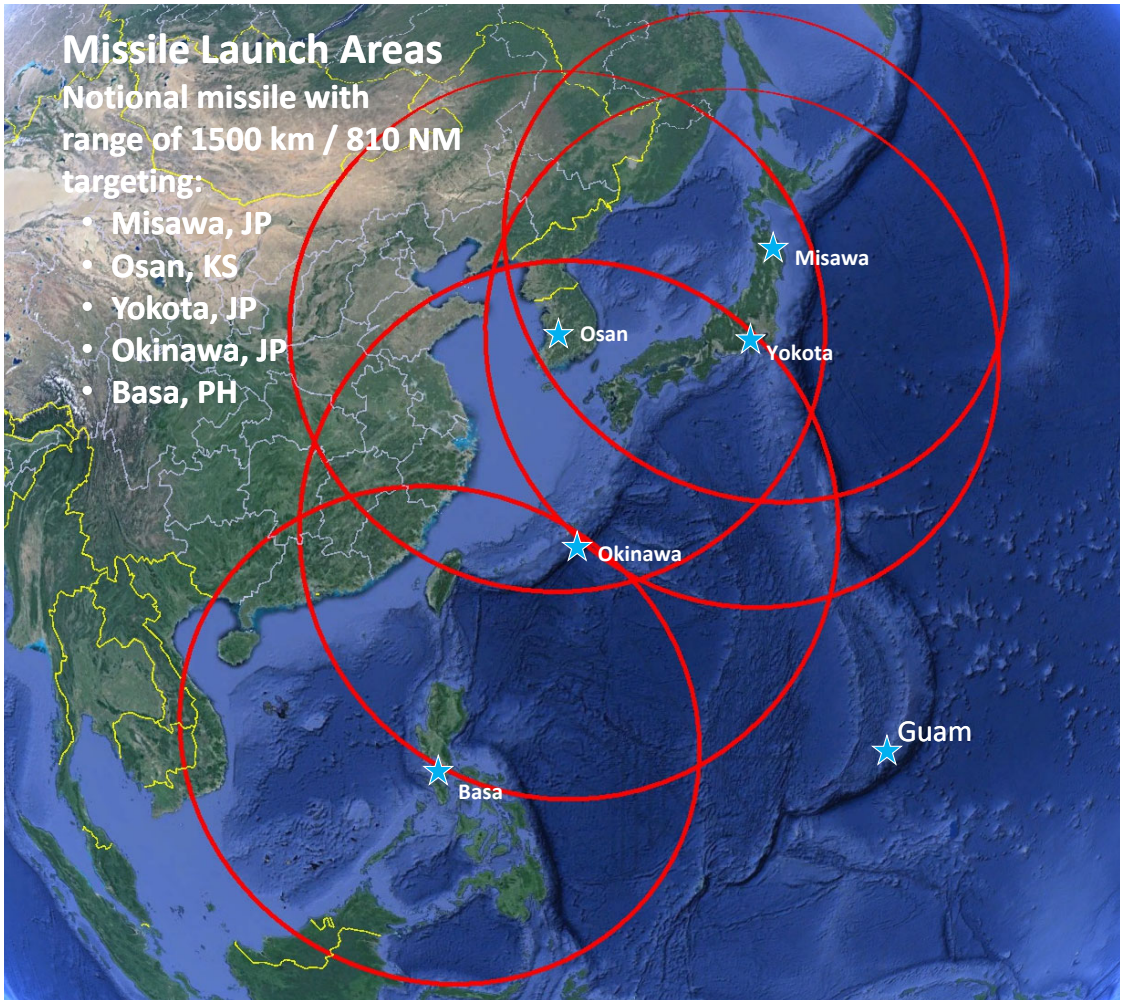

Figure 3: Likely PLA launch areas against select U.S. and allied air bases.

Source: Mitchell Institute.

launched missiles with an effective range of 1,500 kilometers (810 nautical miles). The graphic shows that the PLA would likely need to disperse its MRBMs and cruise missile launchers across different regions—the northeast, east, and southeast PRC—limiting its ability to concentrate missile TELs in any one area. Granted, the 3,000-4,000 km (1,620-2,160 NM) DF-26 can range any U.S. air base out to and including Andersen Air Force Base in Guam. As of 2024, PLA DF-26 brigades have over 200 launchers available. This does not mean the PLA will use every DF-26 to strike Air Force air bases since they will be in great demand for strikes on other high-value targets like U.S. aircraft carrier strike groups and U.S. Navy facilities on Guam. The PLA will also probably hold some DF-26 launchers with nuclear-tipped missiles in reserve, further reducing DF-26 availability for air base attacks.

The PLA is also limited in the number of missile reloads they will have available for an offensive campaign. The Office of the Secretary of Defense's annual China Military Power Report (CMPR) suggests that key long-range DF-26 battalions may only have one reload available—currently about 500 missiles for 250 launchers.[23] MRBMs like the DF-17 hypersonic glide vehicle may have two or three reloads, possibly 432–576 missiles by 2028. PLA "shoot-and-scoot" tactics—rapidly relocating launchers before U.S. and allied strikes—would further reduce missile attack salvo sizes. All these factors combine to limit the number of high-end missiles available for a single strike on U.S. air bases or sustained strikes over time.

Sustaining Air Base Operations Under Attack

To effectively suppress combat sortie generation at U.S. and allied air bases, the PLA will generate sufficient strike volume by combining different types of high-end and low-end weapons. To conduct daily strikes on multiple air bases, the PLA will most likely match a small number of ballistic missiles and HGVs with lower-cost and more readily available ground- and air-launched cruise missiles, as well as long-range drones that include converted uncrewed 2nd and 3rd generation fighter aircraft. U.S. and allied air bases in the Indo-Pacific, especially along the First Island Chain, must be prepared to thwart these attacks with a similarly diverse set of layered active and passive air defenses. Defenses must address detection and targeting threats by adversary ISR as well as provide early warning, deliver kinetic and non-kinetic effects, and provide static protection against strikes by ballistic missiles, hypersonic glide vehicles, aerodynamic missiles, and uncrewed systems. Importantly, it is unlikely that active air defenses will defeat *all* adversary weapons in flight, highlighting an additional critical requirement for air base reconstitution capabilities and rapid runway repair.

The Mitchell Institute and analytic partners conducted an assessment examining sortie generation operations during a notional RED-BLUE conflict in East Asia that shows how a combination of integrated defensive capabilities allows the Air Force to sustain combat-effective sortie generation rates while under enemy fire. In the following scenario, enemy "RED" forces conduct sustained ballistic missile strikes against U.S. and allied "BLUE" air bases located along the First Island Chain. The analysis illustrates how dispersed aircraft operations across multiple locations combined with moderately effective active and passive missile defenses, as well as base recovery and reconstitution capabilities, can enable BLUE fighter and air refueling tankers to quickly return to combat relevant sortie rates while under attack.

The analysis in this scenario measured the effectiveness of BLUE air base defenses in terms of BLUE combat sortie generation. Before aircraft dispersal to remote airfields,

the scenario began with RED ballistic missile attacks against three BLUE main operating bases hosting 24 fighter aircraft each. The scenario also included one BLUE main operating base hosting 36 tanker aircraft. Aircraft dispersal across a network of air bases, along with active and passive defenses in different combinations, successfully defeated a calculated percentage of RED missiles. Active defenses intercepted and destroyed inbound missiles or caused them to miss their intended targets. Passive defenses, including deception, decoys, or hardened facilities, rendered missile strikes ineffective. Based on the number of successful RED missile strikes, BLUE damage and combat sortie generation rates were then calculated.

Analytic assumptions

BLUE force assumptions. Sortie generation modeling in this example included factors such as staggered aircraft launches and landings, mission duration, and time required to refuel and reload aircraft between sorties. The assessment considered requirements for extended maintenance after aircraft flew multiple sorties and assumed fuel, personnel, and munitions were available to support sortie generation while BLUE forces were under attack.

The desired daily sortie rate for BLUE fighters was two sorties per aircraft, assuming each fighter flew 8-hour missions with 2.5 hours between sorties to rearm, refuel, and complete other regeneration tasks. The desired daily sortie rate for BLUE aerial refueling tankers was one sortie per aircraft, assuming each tanker flew 14-hour missions with 4-hour turn times between sorties. Fighters required at least 5,000 feet of usable runway with a width of 50 feet, while tanker aircraft required runways 9,000 feet by 130 feet.[24] Four runway repair crews supported operations at each fighter and tanker base. In the opening hours of the scenario, RED missile attacks temporarily grounded BLUE aircraft until the crews repaired air base runways to the minimum required lengths and widths. Attacks that damaged air base fueling infrastructure in this assessment resulted in a reduction of fueling efficiency that degraded sortie rates. Significantly, the assessment assumed that only BLUE fighters and tankers in the launch queue were vulnerable to RED attacks, while aircraft in the turn process that were parked in maintenance locations—an aircraft shelter or hanger—were protected from attacks.[25]

RED force assumptions. This scenario assumed that RED launched three salvos of 20 ballistic missiles against each BLUE air base (a total of 60 missiles) on the first day of conflict to suppress BLUE sortie generation. RED then launched one attack wave per day for two weeks on each base in an attempt to prevent BLUE from reconstituting its sortie generation operations.[26] RED struck with notional ballistic missiles, each carrying a unitary warhead with a circular error of probability (CEP) accuracy of 5 feet and a destructive blast radius of 100 feet for its air base attacks. Practically, the analysis could substitute RED ballistic missiles with cruise missiles or drones with similar accuracy and blast. The analysis did not consider warheads with sub-munitions that could substantially alter modeled damage. Understanding how RED use of submunitions might impact air base operations are key questions for future analysis. In this case, RED missile attack salvos allocated 50 percent of weapons to runways, while 25 percent targeted aircraft in the open and 25 percent targeted air base fuel stores.

Impacts on sortie generation without air base defenses

Rapid runway repair alone is not enough. As illustrated by the blue line in

Figure 4, BLUE forces maintained a steady-state fighter sortie rate above the desired 2.0 sorties per day when air bases were not under attack. Oscillations in this steady state sortie rate, as shown in Figure 4, were due to periodic fighter maintenance requirements. As illustrated by the red line, three RED attack waves on Day 1 of the campaign effectively shut down the BLUE air base. Runway repair crews reconstituted BLUE fighter sortie rates at the air base to approximately 0.85 sorties per aircraft per day by Day 4 of the conflict. This is a 60 percent reduction compared to steady-state sortie generation not under attack.

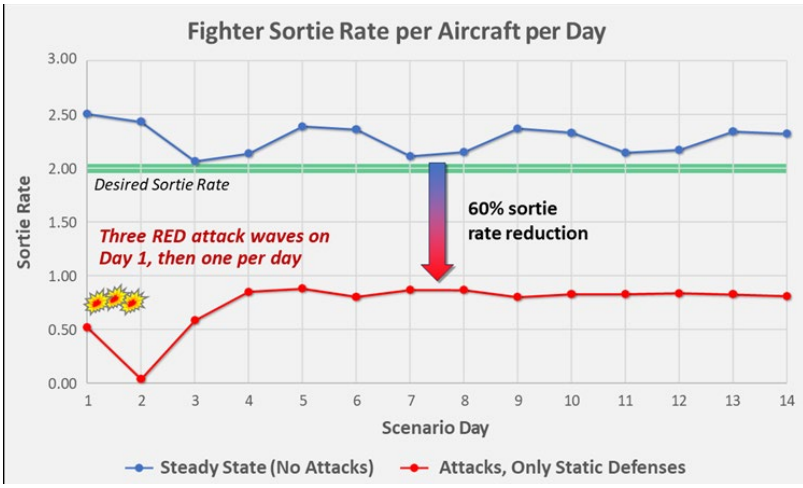

Figure 4: BLUE fighter daily sortie rates while under attack by RED missile forces (red line), assuming four rapid runway repair teams are available at each fighter air base, no missile defenses, and no dispersal.

Source: Mitchell Institute.

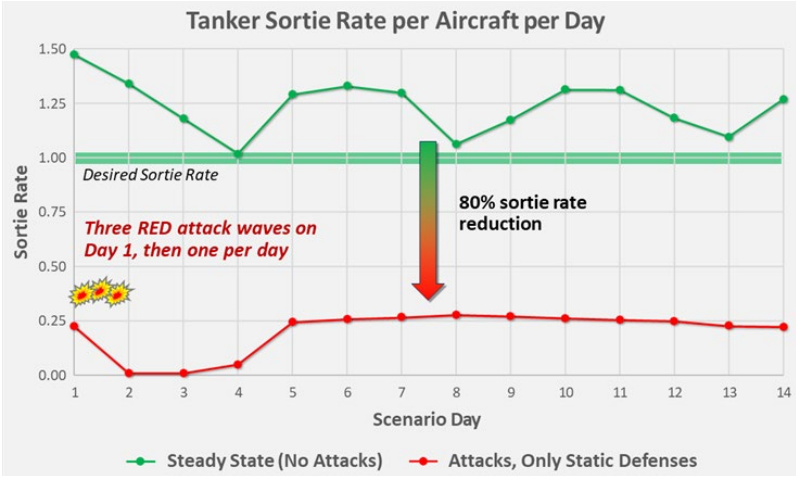

Figure 5: BLUE tanker daily sortie rates while under attack by RED missile forces (red line), assuming four rapid runway repair teams are available at the tanker base, no missile defenses, and no dispersal.

Source: Mitchell Institute.

As shown in Figure 5, BLUE tankers maintained a steady-state sortie rate above the desired 1.0 sortie per aircraft per day when their air bases were not under attack. Again, periodic tanker maintenance requirements cause oscillations in the steady-state sortie rate, as shown by the dotted green line in Figure 5. The three RED missile attack waves on the BLUE tanker base during the first day of combat had a much greater impact on tanker sortie rates compared to BLUE's fighter rates, principally due to the need to repair longer and wider runways for the tankers following the attacks. The reduction in ground refueling efficiency also had a greater impact on turning tankers between sorties. Because of these factors, the tanker daily sortie rates averaged approximately 0.25 sorties per aircraft by Day 5 of the air campaign, an average of one sortie per aircraft every four days. This represented an 80 percent reduction compared to the steady-state sortie generation rate when air bases were not under attack.

This simplistic assessment illustrates the *potential* impact of sustained missile attacks on the Air Force's sortie generation rates during a conflict in the Indo-Pacific. The actual impact of Chinese missile attacks on U.S. air bases in the Pacific would likely be greater than this example suggests. For instance, the reduced availability of aerial refueling due to attacks on tanker bases would significantly reduce the Air Force's fighter operational tempo. If missile attacks reduced tanker sortie rates by 80 percent, the service's fighter forces would have to fly fewer sorties per day, reduce their mission durations, or both.

In a more comprehensive assessment considering the synergies between attacks on fighter bases and tanker bases, Air Force fighters may have to return to base more often to refuel, in which case runway

damage at fighter bases would have a greater impact on sortie generation. Moreover, returning to base more often to refuel would mean more time on the ground increasing fighter aircraft vulnerability to missile attacks. Reduced fighter and tanker sortie rates and increased attrition on the ground could have a decisive impact on a campaign against an adversary, especially in the opening days of a conflict. However, the following examples demonstrate how a combination of dispersed operations, air base active and passive missile defenses, and rapid air base repair allow rapid regeneration of combat-relevant sortie rates.

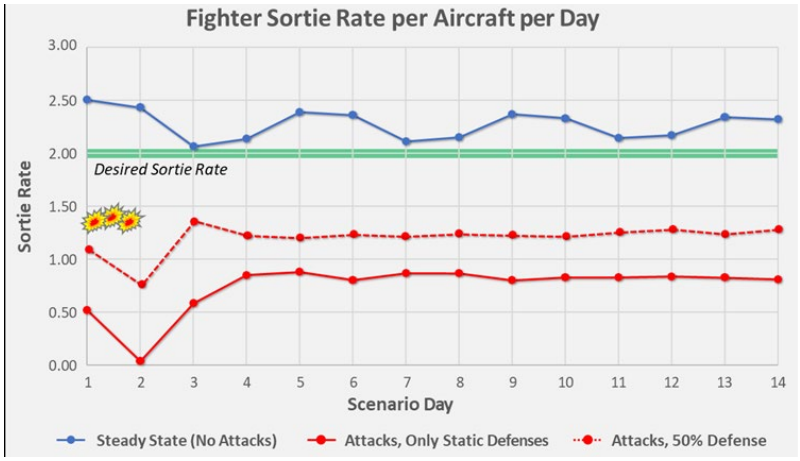

Figure 6: Active and passive missile defenses combined with rapid runway repair increased BLUE fighter sortie generation rates (dashed red lines) while air bases were under attack over the baseline case without missile defenses (solid red lines).

Source: Mitchell Institute.

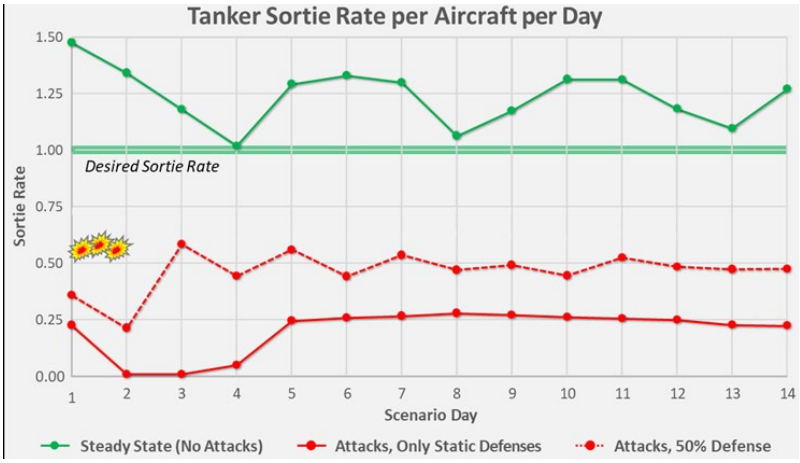

Figure 7: Active and passive missile defenses combined with rapid runway repair increased BLUE tanker sortie generation rates (dashed red lines) while air bases were under attack over the baseline case without missile defenses (solid red lines).

Source: Mitchell Institute.

Generating combat sorties under attack

A combination of missile defenses and rapid runway repair improve sortie generation rates. The dashed red line in Figure 6 illustrates how defeating 50 percent of inbound missiles in each RED attack wave doubles the fighter sortie rate on Day 1 of the air campaign compared to the sortie rate with no base defenses, depicted by the solid red line. Within several days, daily fighter sortie rates would increase to an average of about 1.25 sorties per fighter per day as repair crews reconstituted air base runways. This is also the case for the air refueling tanker bases.

As depicted in Figure 7, defenses that defeated 50 percent of inbound RED missiles significantly increased the tanker daily sortie rate compared to air base operations without active and passive missile defenses. By Day 3 of the campaign, tanker rates recovered to about 0.5 sorties per day, half the desired rate.

Dispersed aircraft operations plus rapid runway repair were even more effective. The ACE concept disperses combat sortie generation operations across multiple operating locations. Aircraft dispersal complicates an enemy's ability to target and concentrate its air and missile attacks on a small number of main operating bases. For the purposes of this assessment, each BLUE fighter and tanker squadron split operations between one ACE "hub" air base and four "spoke" contingency locations.

ACE hub and spoke dispersal operations proved to be the single most effective measure for regenerating BLUE's desired fighter and tanker sortie rates. ACE dispersal operations combined with rapid runway repair increased daily fighter sortie generation rates to 1.5 sorties per aircraft per day, as shown by the purple line in Figure 8. These results assumed that RED used the same number of weapons in each attack

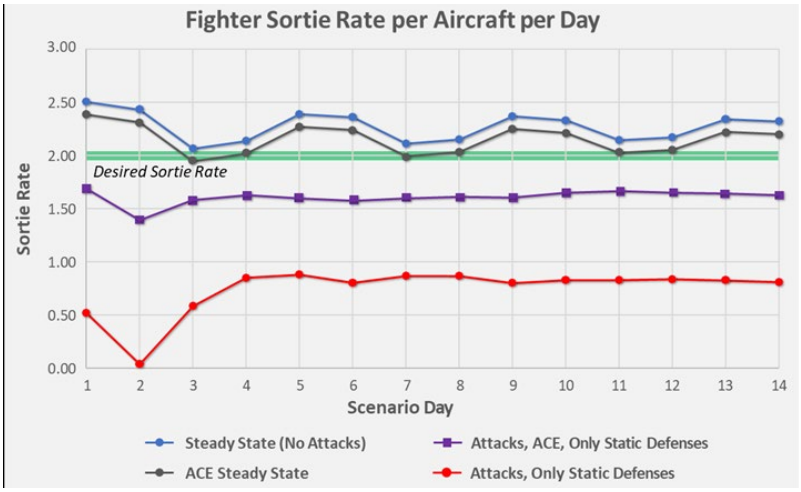

Figure 8: BLUE fighter sortie rate while under RED attack assuming each tanker squadron is operating from a dispersed ACE posture of one "hub" base and four "spoke" locations.

Source: Mitchell Institute.

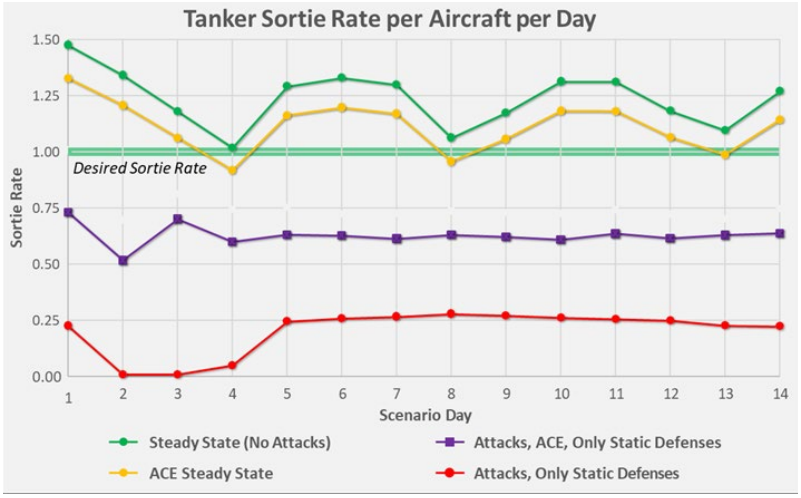

Figure 9: BLUE tanker sortie rate while under RED attack assuming each tanker squadron is operating from a dispersed ACE posture of one "hub" base and four "spoke" locations.

Source: Mitchell Institute.

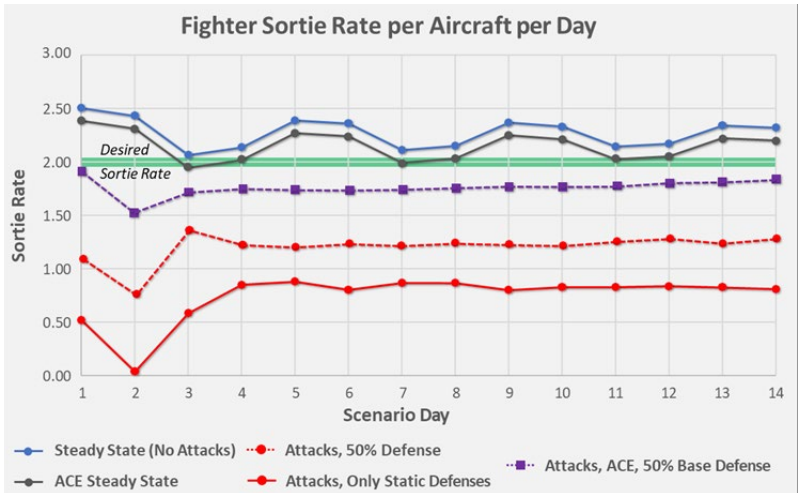

Figure 10: BLUE fighter sortie rates while under attack assuming 50% effective air base defenses, ACE dispersal, and rapid runway repair at each hub and spoke operating location.

Source: Mitchell Institute.

wave of 20 missiles but had to spread those missile attacks across all hub and spoke bases—four missiles attacking five different operating locations.

Taking dispersal into account, daily tanker sortie generation rates in the face of RED attacks remained above 0.5 sorties per aircraft and stabilized at 0.6 sorties per day by Day 3 of the air campaign, as shown by the purple line in Figure 9. This illustrates how ACE hub and spoke dispersal approach can increase BLUE's combat generation capacity under attack. However, different RED attack strategies could have a greater impact on air base operations. RED might adopt a strategy of attempting to suppress one hub at a time, which could degrade resupply and maintenance operations at the hub's respective spoke dispersal air bases. Extended maintenance for aircraft located away from the hubs for several days might also significantly impact sortie generation rates at the spoke bases.

A combination of active and passive defenses, ACE, and rapid runway repair. A combination of rapid runway repair, ACE hub and spoke dispersal, and defenses that defeated 50 percent of inbound missile attacks allowed for the best BLUE fighter and tanker sortie rates while air bases were under sustained RED attack. Figure 10 shows that this combination of measures allowed BLUE to maintain an operational tempo of 1.75 sorties per day for each fighter while under RED attack, 88 percent of the desired sortie rate, as depicted by the purple dashed line.

Figure 11 shows that the same combination of measures allowed sustained daily tanker sortie rates of 0.75 sorties per aircraft per day while under RED attack, 75 percent of the desired sortie rate, as depicted by the purple dashed line.

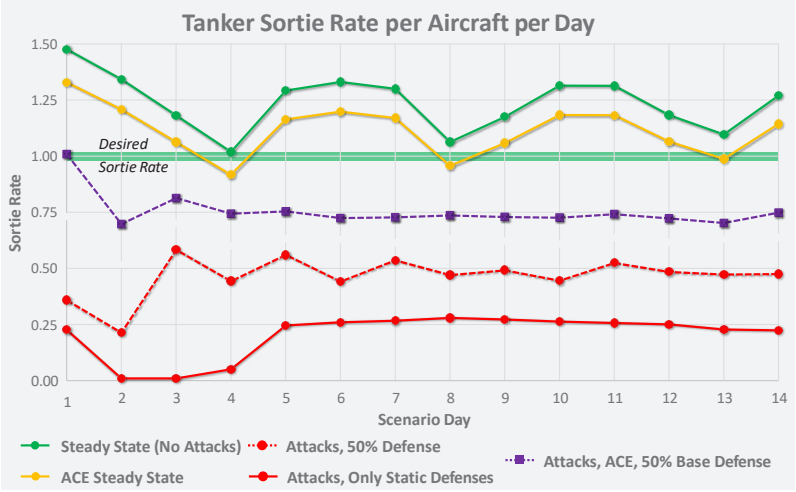

Figure 11: BLUE tanker sortie rate under RED attack with ACE dispersal and 50% defense.

Source: Mitchell Institute.

Need for a combination of defensive measures

This assessment demonstrates that a combination of substantial rapid runway repair capabilities, active and passive defenses that defeat at least 50 percent of RED missile strikes, and dispersed operations across multiple air bases yielded the best results. In the face of an initial surge of three attack waves followed by sustained, daily attacks, BLUE forces were able to generate 88 percent of their desired fighter sortie generation rate and 75 percent of their desired tanker sortie rate. The assessment also indicates that ACE air base dispersal had a greater impact on improving sortie generation than air base defenses that defeated 50 percent of inbound missiles alone. Importantly, tanker support is critical to enable the long-duration (8-hour) fighter missions calculated in this scenario. The assessment shows that tankers could continue to operate at 0.75 sorties per day throughout the conflict—if BLUE forces employed ACE dispersion, moderate defense against inbound missile attacks, and rapid runway repair. Without those measures, tankers suffered a potentially catastrophic four-day air base shutdown at the beginning of the scenario, which could effectively enable an adversary *fait accompli*.

Caveats. More comprehensive assessments of approaches to improve the Air Force's sortie generation rates while under attack should consider the increased equipment, logistics, and personnel burden inherent in executing the ACE dispersal concept. ACE requires adequate numbers of runway repair crews as well as active defense systems spread across all hub and spoke bases. A minimum level of defensive capabilities and reconstitution capabilities at each location would also be necessary to return an air base to operational status if RED chose to focus all of its attacks on one particular air base.

Moreover, the protection offered by aircraft maintenance hangers assumed in this assessment probably does not reflect real-world conditions or, potentially, RED targeting strategies. That is, the assessment assumed that BLUE aircraft were not vulnerable to RED missile attacks while in maintenance areas—hangers or hardened aircraft shelters. Unreinforced hangers and shelters offer little protection against direct attack by most long-range munitions delivering unitary warheads. Substantial, hardened aircraft shelters offer protection against cruise missiles, drones, sub-munitions, and other weapons with fragmenting warheads. However, even hardened aircraft shelters may not protect aircraft from a direct hit by a missile with a large, penetrating warhead. However, an abundance of hangers and shelters may offer passive "shell game" protection. In other words, if RED missiles can only target a percentage of an air base's numerous hangers and shelters, they are less likely to find actual aircraft dispersed within them. Moreover, RED missile attacks against hangers, overhead shelters, and hardened aircraft shelters would likely increase BLUE aircraft ground losses over time.

Additional, higher fidelity modeling and assessments will help the Air Force further refine its air base defense requirements. Analytic exclusions examined for this report indicated that 50 percent of aircraft were lost in RED air base attacks over two weeks. One RED targeting strategy might be to attack and destroy all hardened aircraft shelters at an air base with penetrating warheads in its initial attack waves. Then, even if aircraft were airborne during RED attacks, the lack of available hardened shelters would leave aircraft exposed and more vulnerable to follow-on RED air base attacks with cluster munitions. RED attacks on BLUE runways timed for when aircraft are returning to base and short on fuel may also have outsized impacts on aircraft losses and air base operations. Finally, air base fuel storage and personnel must be carefully considered since they may be impossible to replace in a weeks- or months-long conflict.[27]

Overall, however, this example illustrates the value of dispersing the Air Force's combat aircraft across multiple air bases and the absolute necessity of robust rapid runway repair capabilities to return air bases to operational status after attacks. U.S. and allied air forces can achieve combat relevant sortie rates while under enemy fire—if the Congress and DOD provide the resources necessary to implement ACE, field cost-effective active and passive missile defenses, and develop the capacity to rapidly reconstitute operations at all of its established and dispersed air bases in the wake of attacks.

An Operational Concept for Air Base Defense

The analysis of the mix of likely threats to U.S. air bases from a near-peer adversary and proof-of-concept modeling about requirements for combat sortie generation under fire reveal some key principles that should shape an operational concept for DOD's air base defense priorities:

Understanding "Operational Concept" versus "CONOPS"

An operational concept is a method for employing military capabilities. This term is distinct from "concept of operations" or CONOPS, which describes how a commander will use resources to accomplish a particular mission or operation, usually in a specific place, at a specific time. Operational concepts informally reflect the assumptions and intent of military leadership and form the basis for operational planning or force development.

1. The Air Force's ACE concept featuring air base and aircraft dispersal can significantly improve sortie generation and regeneration efforts during a conflict;
2. A diverse, layered arsenal of active defenses that includes survivable, distributed active and passive sensors as well as kinetic and non-kinetic effectors that can provide cost-effective protection against incoming attacks; and
3. Passive defenses, including hardening and substantial reconstitution capabilities, especially rapid runway repair, are essential for regenerating combat power following air base attacks.

Figure 12 is an overview of an air base defense operational concept built on these three insights. Although not depicted in Figure 12, air base dispersal is potentially the concept's most effective single countermeasure, as it can create targeting dilemmas and reduce the size of weapon salvos an adversary can concentrate against any one air base. Active defenses should be diverse, layered, and modular to further complicate adversary planning and weapons employment. For example, the concept places airborne assets in an outer kill layer to detect and engage threats, especially low-flying threats like cruise missiles.[28] Theater air defense assets

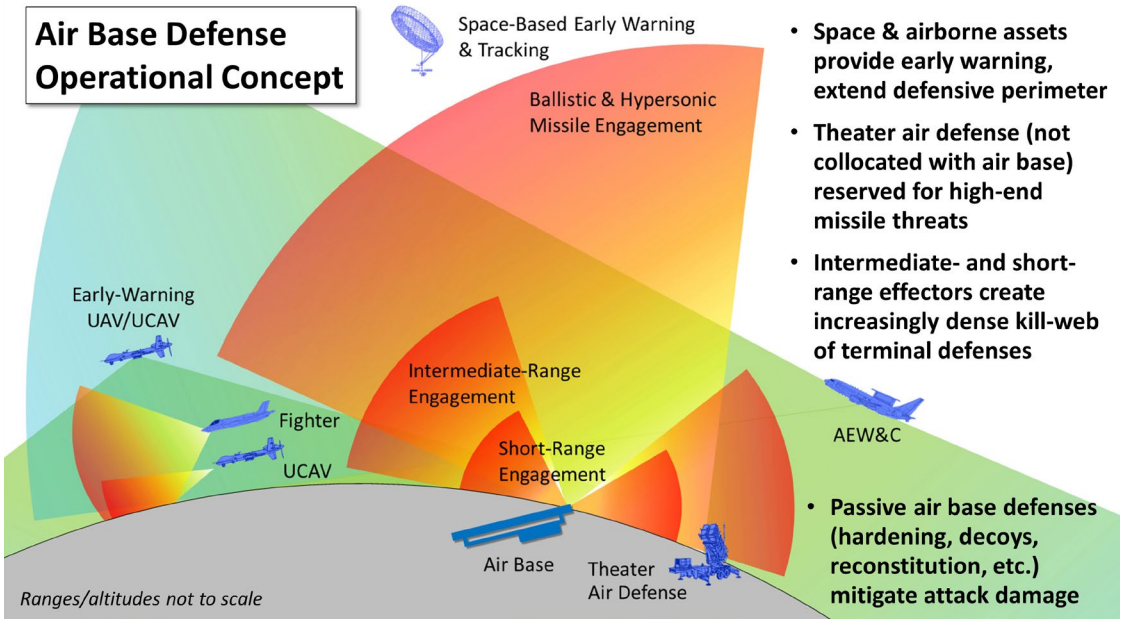

Figure 12: Proposed air base defense operational concept.

Source: Mitchell Institute.

such as the Army's Theater High-Altitude Area Defense (THAAD) and Patriot surface-to-air missiles or Navy Standard Missiles do not necessarily have to be collocated with the air base and can provide long-range defense against high-end threats like ballistic missiles and hypersonic glide vehicles. Intermediate- and short-range air defense systems, located at or near the air base, offer a coordinated kill-web of increasingly dense terminal defenses as threats approach the base.

There are no silver bullets—no magic weapons that will solve the air base defense challenges the Air Force faces.

This air defense design, with an outer detection and kill zone as well as an inner kill zone, complements scarce and expensive long-range air defense capabilities like THAAD and Patriot with more cost-effective and combat-relevant airborne, intermediate-range, and short-range effectors, including electronic warfare and directed energy weapons. Airborne assets operating at longer ranges from the air base may be able to engage these inbound threats while also providing early warning of low-flying inbound threats for other defenses. However, intermediate- and short-range systems are still necessary to address larger volumes of lower-end air and missile threats such as aircraft, cruise missiles, and drones. There are no silver bullets—no magic weapons that will solve the air base defense challenges the Air Force faces. Practical, effective, and enduring air base defense requires an enterprise approach.

This air base defense concept may appear to increase risk in that some threats may need to be allowed to close in on an air base in exchange for cost-effectiveness. Ideally, U.S. defenders would engage threats as far away as possible from an important asset like an air base. The reality is that a long-range intercept strategy threatens to quickly exhaust highly capable long-range interceptors against what may be a large volume of relatively low-cost enemy weapons. For example, a single Patriot and a THAAD surface-to-air missile cost $3.8 million and $8.4 million, respectively.[29] If lower-end inbound threats like cruise missiles and drones cannot be engaged by airborne assets, an air base's intermediate- and short-range kill web could address those threats. Allowing threats to approach air bases and then engaging them with

reliable, lower-cost, short-range air defenses reduces operational risk over time in the face of sustained air and missile attacks. This concept reserves long-range and more expensive high-end defensive weapons like Patriot and THAADs for high-end, difficult-to-defeat threats.

To address threats that may ultimately evade active defenses, air base hardening, camouflage, concealment, and deception are important passive air defense components of this operational concept. These measures are also typically highly cost-effective. Redundancy in vital systems, such as fuel and power generation, and other reconstitution capabilities are necessary to return the air base to operational status following an attack. Rapid runway repair capabilities to quickly reconstitute the minimum operating runway lengths for aircraft are among the most essential elements of an operational concept that returns sortie generation to combat relevant levels in the wake of attacks.

The following sections go into further detail on the principles that underpin this air base defense operational concept.

Agile Combat Employment

Aircraft dispersal across multiple air bases and alternate operating locations complicates adversary targeting with simple math while still allowing the Air Force to hold targets at risk from multiple forward locations. In an East Asia conflict scenario, the U.S. Air Force may operate from air bases spread across a 2,000–3,000 nautical mile front. In a conflict, an adversary like China's PLA would consequently need to spread its ISR and strike capabilities across the entire front, increasing costs for the PLA and potentially reducing the size of an attack against any one base. Alternatively, if a PLA targeting strategy focused on just a few bases, other distributed bases would be allowed to operate free from sustained attacks.

This report's proposed operational concept for air base defense builds on the aircraft dispersal inherent in the ACE concept, the Air Force's contribution to the DOD Joint Warfighting Concept's "expanded maneuver" concept. ACE purports to consist of five core elements: posture, command and control (C2), movement and maneuver, protection, and sustainment. Fundamentally, however, the first element—posture, or expanding the distribution of forces within a theater of operations—is the central feature of the ACE concept. According to ACE doctrine, "Forces must be able to rapidly execute operations from various locations with integrated capabilities and interoperability across the core functions."[30] Aircraft dispersal across multiple air bases, combined with substantial passive and active defenses, can help diffuse enemy air and missile strike capacity and effectiveness. It mitigates risk by shifting the Air Force's sortie generation operations from a small number of centralized theater air bases to a network of smaller bases and operating locations.

Understanding air base defense service responsibilities

Before addressing specific active and passive defense capabilities, it is important to understand the roles and missions of the services for air base defense and the need for DOD to clarify those responsibilities. Only the Air Force can provide the volume of airpower necessary for a combatant commander to succeed in large-scale joint combat operations. Therefore, the combatant commands have the greatest stake in ensuring air bases have effective active and passive defenses to enable the ultimate success of joint operations. The Army, Navy, and Marine Corps, in their organize, train, and equip roles, have a fundamental responsibility for the

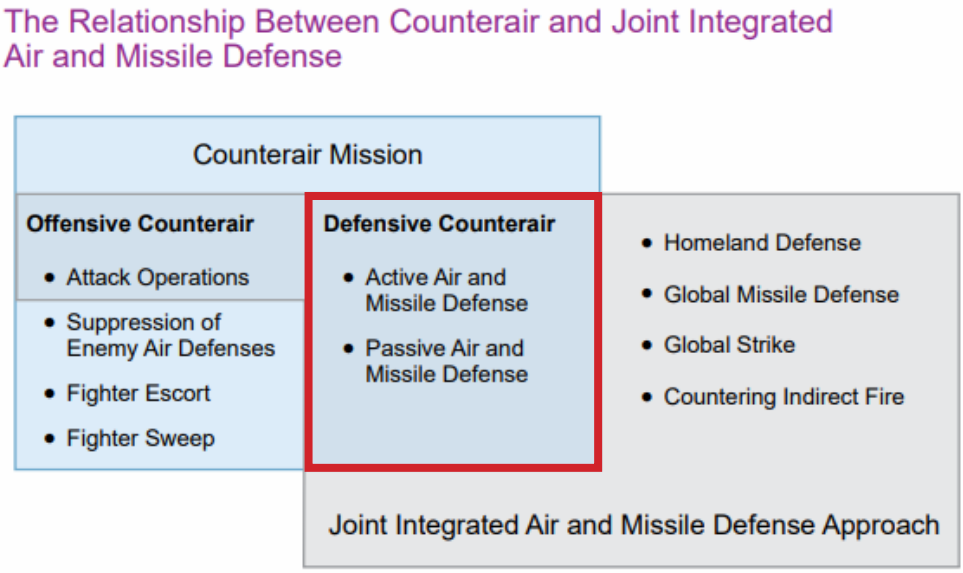

Figure 13: Defensive counterair as a core element of joint integrated air and missile defense.

Source: AFDP 3-01, originally Joint Chiefs of Staff, *Countering Air and Missile Threats*, JP 3-01 (Washington, DC: Joint Chiefs of Staff, April 6, 2023), p.I-13.

protection of their forces. These services have organic ground- or surface-based active defenses to protect forces and bases. Despite the fact that the Air Force bears overarching responsibility for the defensive counterair (DCA) mission, the Air Force does not control all the forces necessary for base defense. While the Air Force is responsible for passive base defenses and active airborne defenses, the Department of the Air Force (DAF) statement on its approach to *Resilient Forward Basing* reads, "Active defenses should be provided by [the DAF's] Joint Force partners."[31] In other words, the Air Force has long maintained that the U.S. Army is primarily responsible for providing active ground-based defenses for the Air Force's air bases.[32] Given the competing priorities, air base defense resourcing responsibilities are complex and interconnected between the services and the combatant commands.

Several U.S. military doctrinal publications define the constituent elements of air and missile defense, including Joint Air Operations (JP 3-30), Countering Air and Missile Threats (JP 3-01), and Counterair Operations (AFDP 3-01). These documents outline requirements for defensive counterair (DCA) operations, which include both active and passive defenses, as well as requirements for air base reconstitution. The DCA active and passive defenses, in particular, are core components of joint integrated air and missile defense (IAMD). Offensive counterair (OCA)—attacking, disabling, and destroying enemy forces before they can attack U.S. air bases—will certainly be an important contribution to air base defense. This proposed concept for air base defense focuses on DCA and constituent active and passive air and missile defenses (AMD), as depicted in the red box in Figure 13.

Typically, for any large-scale, joint operation, Air Force commanders are the most appropriate selection for the position of Joint Force Air Component Commander (JFACC) and Area Air Defense Commander (AADC) with overall responsibility for DCA and OCA.[33] The Army and potentially the Navy have a responsibility to support the JFACC and AADC with ground-based or surface-based active air defense capabilities. Table 2 delineates service responsibilities for air base defense and DCA across different command and air defense categories.

Responsibility	Primary – P		Secondary/Supporting Role – S	
	Air Force	Army	Navy	Space Force
Joint Force Air Component Commander (JFACC)	P			
Area Air Defense Commander (AADC)	P			
Deputy Area Air Defense Commander (DAADC)		P	P	
Ground-/surface-based AMD (SAMs & AAA)		P	P	
Airborne AMD (air-to-air)	P		S	
Ground-/surface-based electronic attack	S	P	S	
Airborne electronic attack	P		S	
Attack detection/early-warning	P	S	S	S
Aircraft & air base dispersal	P			
Hardening	P			
Camouflage, concealment, deception	P			
Reconstitution of air base functions	P			
Rapid runway repair	P			

Table 2. Responsibilities for active and passive air defense (DCA) for air bases

All U.S. military services perform functions that serve a joint or combined purpose for air and missile defense. In fact, DOD Directive 5100.01 clarifies that missile defense is a common function across all services.[34] However, while U.S. Army ground-based or U.S. Navy surface-based active air defense capabilities, including SAMs, AAA, directed energy, and electronic attack, are important components for air base defense, **institutional gaps in Army and Navy support for Air Force air base defense has persisted for decades.** The Army and the Navy have and continue to prioritize AMD functionality to support their individual service missions. The Army optimizes air defense to support its maneuver units, while the Navy optimizes capabilities to provide fleet air defense. The Air Force should also be equipped to protect its forces at its operating bases. Ultimately, however, the Air Force has overarching responsibility for the coordination and execution of DCA and air base defense in forward areas but does not procure and maintain any ground- or surface-based air defense weapons.

Given this reality and the different service priorities, Congress and the DOD should clearly delineate which service must procure, maintain, and operate ground- or surface-based active air defense capabilities for air bases and then resource them accordingly. More significantly, DOD leadership will need to define what existing service capabilities should be reserved for forward air base defense. In the face of significant financial constraints caused by modernization requirements on the Air Force and other services, Congress must accept that, in the face of growing threats to air bases and other critical theater defense infrastructure, additional funding for air defense must be additive and cannot simply be carved from existing budgets.

Air base passive defense measures

Passive defenses are some of the most cost-effective contributions to air base defense. Compared to relatively expensive air-to-air and surface-to-air missiles, passive defenses offer persistent, layered, and redundant capabilities that may significantly increase adversary costs in terms of ISR,

missiles, and drones that will be challenged to find or effectively target friendly forces.

Aircraft dispersal is a priority. As illustrated by this report's sortie generation assessment, Agile Combat Employment hub and spoke dispersal operations may be the single most effective measure for preserving aircraft combat sortie rates. Whether in Europe, Southwest Asia, or the Indo-Pacific, aircraft dispersal across multiple air bases complicates adversary targeting while still allowing the Air Force to hold adversary targets at risk from multiple forward air bases. Dispersal also increases an adversary's cost in resources to effectively target U.S. air bases and ultimately reduces the size of attacks against any one base. With ACE implemented, an adversary like China's PLA might need to spread ISR and strike capabilities among Air Force air bases spread across a 2,000–3,000 nautical mile front. Geopolitically, air base dispersal in multiple allied and partner nations also puts aggressors in the potentially perilous position of expanding a conflict by striking U.S. forces operating inside other nations' borders.

Cost-effective camouflage, concealment, and deception (CCD). CCD is among the most cost-effective defensive measures the Air Force can undertake to confound adversary targeting and minimize the effectiveness of attacks on air bases. CCD includes a wide variety of relatively inexpensive but potentially decisive measures ranging from rigid or inflatable decoys of aircraft to camouflage netting, or radar-reflective covers that obscure the telltale shape and signature of a parked aircraft. Deception measures can also include cyber deception or electronic decoys to fool an adversary into believing an air base is occupied when it is not. Even large tanker and ISR aircraft can benefit from CCD measures. The PLA Air Force, for its part, has invested in significant numbers of overhead shelters at front-line airfields that obscure the presence of even the largest PLA aircraft (see Figure 14).

There is little public evidence that the Air Force is actively pursuing CCD measures on a large enough scale to effectively defend against an adversary like the PLA. The *Air Force Doctrine Note on Agile Combat Employment*, its narrative on *Resilient Forward Basing*, and

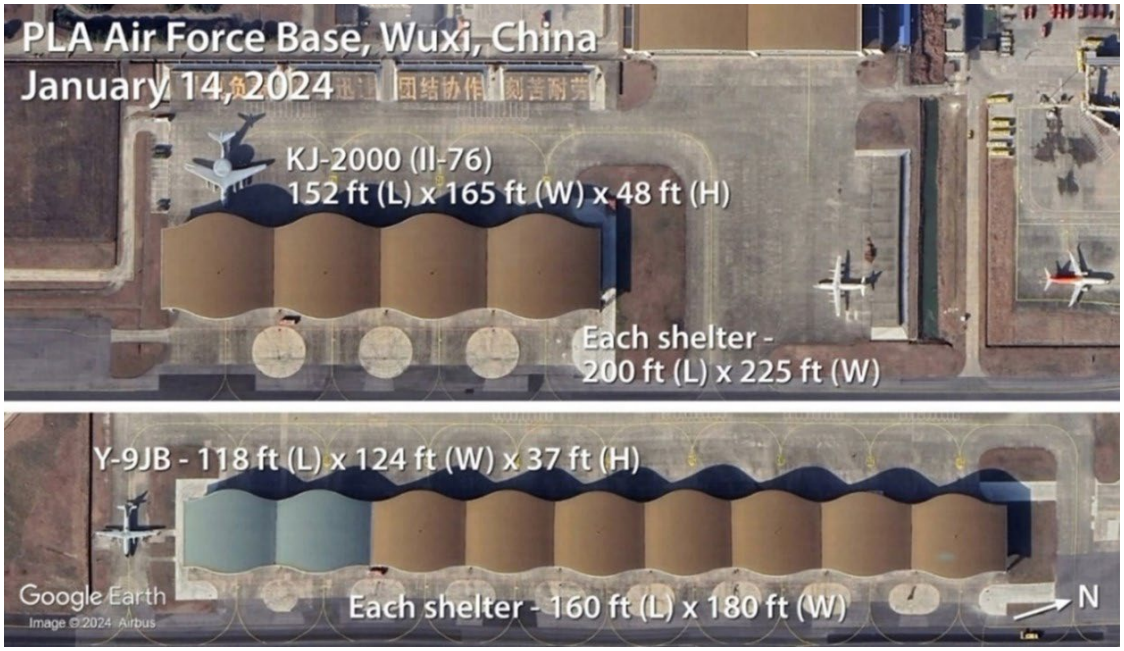

Figure 14: Large aircraft shelters at PLA Air Force Air Base, Wuxi, PRC. Almost all frontline PRC military airfields have these types of shelters to mask the presence or absence of fighters, bombers, and special mission aircraft.

Source: Google Earth Pro 7.3.6.9796, January 14, 2024, Wuxi, China, 36.497N, 120.431E, Airbus 2024 .

other Air Force strategy documents make only passing references to these types of defenses, while the *Pacific Air Force's Strategy 2030* simply states, "We are diversifying our defenses to include additional camouflage, concealment, and deception, infrastructure hardening, and active defense capabilities."[35] CCD should be a core element of air base defense, not an ancillary capability.

The Air Force is reportedly purchasing an undetermined number of Expedient Small Aircraft Shelters (ESAP) that it could deploy to austere locations.[36] ESAP are fully enclosed steel shelters that may house equipment or fighter-sized aircraft.[37] While steel-sided shelters offer aircraft and personnel limited protection from small drones or shrapnel, they would not survive a direct hit by kinetic weapons carrying larger warheads. By potentially offering protection against sub-munitions, the shelters may drive an adversary to use more unitary warheads, driving up the number of missiles needed in an air base attack. The Air Force also appears to have a limited supply of tent-like Large Area Maintenance Shelters (LAMS) that could serve as temporary shelters to hide aircraft from overhead ISR.[38] The widespread use of temporary shelters and overhead shelters would likewise increase the number of munitions an adversary must expend to attack an air base. These measures would enable the Air Force to employ a shell game defense that moves its dispersed aircraft among potentially dozens of shelters across different air bases. This shell game would cause an adversary to guess which shelters are occupied by actual aircraft and possibly waste costly precision attack munitions on empty targets.

Hardened aircraft shelters (HAS) complicate adversary attacks. HAS also offers cost-effective protection for aircraft and personnel against a wide variety of potential enemy weapons. Depending on construction, a HAS that can house a single fighter will protect against strikes by most weapons, including rockets, mortars, cruise missiles, and drones. Many may not withstand a direct hit by a ballistic missile or other penetrating munition, but the requirement for direct hits, especially at long ranges, may again drive up adversary costs and the need to employ multiple weapons to achieve a single direct hit. HAS, like the aforementioned temporary shelters or overhead shelters, also allow for an aircraft dispersal shell game that adds uncertainty to adversary targeting efforts. Open-ended flow-through shelters provide protection for fighter maintenance and refueling. These steel and reinforced concrete permanent structures cost between $1 million and $3 million each.[39] More substantially constructed HAS that are fully enclosed with blast doors and ventilation systems may cost between $4 million and $6 million each.[40] To put these figures in perspective, a $4 million fully-enclosed, substantial hardened aircraft shelter that may last for decades costs as much as a single Patriot surface-to-air missile or 1/20 the cost of an $80 million fighter aircraft that the HAS might otherwise protect.

Rapid runway repair. Rapid runway repair, also known as rapid airfield damage recovery (RADR), is a set of capabilities necessary to return an air base to operational status following enemy attacks. The Air Force is significantly underinvested in RADR capabilities to support the ACE concept. This is especially significant in an East Asian conflict in which the Air Force may disperse air bases across a front of several thousand miles. RADR personnel, equipment, and materiel would likely need to be prepositioned prior to a conflict to facilitate the "rapid" requirement of the equation, as these elements would not be easily relocated under enemy fire.

Since 2021, the Air Force has been experimenting with capabilities called expedient and expeditionary airfield damage repair, or E-ADR. The requirements outlined

in the initial E-ADR program were to deploy materiel and equipment on only four C-130 transport aircraft that could backfill and resurface up to 18 craters in 24–36 hours. The requirement for repaired pavement supports 500 passes by an Air Force fighter aircraft.[41] The Air Force continues to experiment with lighter and leaner E-ADR equipment with as few as 16 personnel per runway repair team.[42]

As the Air Force continues to build out its rapid runway repair capabilities, it should set goals for decreasing repair times from days to hours. New and novel materials and repair techniques, including rapid setting materials, mixing cement to stabilize on-site materials, and foam backfill, may reduce the size of runway repair crews and the footprint of equipment with the promise of decreasing repair times.[43] For instance, a rapid runway repair exercise at a former NATO base in April 2024 saw the first operational landing of aircraft on a fiber-reinforced polymer matting system (FRP) used to cover rapidly repaired surfaces.[44] These relatively low-cost capabilities will be instrumental in ensuring the Air Force is able to generate decisive combat power in future conflicts.

Damage control, medical, and other reconstitution capabilities. The Air Force's Cold War-era Salty Demo air base defense exercise engulfed an entire U.S. air base in a simulated Soviet attack. The exercise replicated fires, collapsed buildings, massive personnel casualties, power and communications outages, and unexploded ordnance scattered across the base, demonstrating that air base reconstitution requirements extended well beyond protecting aircraft and repairing cratered runways. Coping with widespread damage will significantly reduce the ability of the Air Force's air bases to generate combat power. Ensuring combat sortie generation at dispersed air bases under sustained attack during a conflict with a near-peer adversary in the future will likely require substantial forward-deployed firefighting, medical, utility repair, fuel service repair, and explosive ordnance disposal capabilities at each dispersed air base. Exercising reconstitution capabilities will be fundamental in preparing airmen for "the synergistic chaos" that may follow a large-scale enemy attack.

Active Air Base Defense Measures

Advanced early warning is imperative. Early warning of inbound enemy attacks—whether days, hours, or minutes—affords air base personnel opportunities to take shelter and implement countermeasures. Early warning and tracking inbound threats provide a bridge to active defenses such as airborne interceptors, surface-to-air missiles, or directed energy weapons. Advance warning also allows aircraft to launch to intercept inbound threats and provides ground-based systems with cues on when low-altitude or hypersonic threats will come into engagement range, which may only be seconds before impact. Long-range interceptors may also engage inbound threats that are over-the-horizon using precise tracking data from early warning platforms. Among the lessons learned from Iran's attack with over 300 drones and missiles against Israel in April 2024 was the critical role that early warning played in the successful defeat of 99 percent of the Iranian weapons.[45] Early warning allowed fighters, tankers, and airborne command and control to surge forward to meet this attack, while tactical early warning allowed forces to position and effectively locate Iran's attack waves.

Space-based surveillance, like the Space-based Infrared System-High (SIBRS-HIGH), will likely provide the first warning of inbound missile attacks against air bases.[46] Air surveillance aircraft like the E-7A Wedgetail airborne early warning and control (AEW&C) system and networked sensors onboard F-35 fighters may also provide decisive long-range early warning and tracking capabilities. Uncrewed autonomous or remotely piloted aerial vehicles (UAV) may also serve as long-

range patrols or sentries near air bases to warn of inbound enemy attacks. Since 2022, MQ-9A and MQ-9B UAVs have demonstrated the effectiveness of their actively electronically scanned array (AESA) radars. UAVs have the advantage of very long sortie times—over 24 hours inflight—which can greatly enhance an air base's early warning capacity.[47] In addition to providing early warning and forwarding tracking information to other defenders, aircraft like the F-35 and MQ-9 could also act as front-line defenders, launching air-to-air weapons against inbound threats. The Air Force must rethink how to best use assets already in its inventory against new challenges such as air base defense.

Air-to-air interceptors are part of the mix. Air-to-air interceptors, whether launched by crewed fighter aircraft, uncrewed collaborative combat aircraft (CCA), or other UAVs, will be an important component of an integrated, layered air base defense concept. Sorting, targeting, and engaging inbound threats to thin attack salvos before they reach an air base will increase the likelihood of success for the air base's ground-based surface-to-air missiles and other terminal defenses. While details are still emerging, it appears that crewed aircraft using air-to-air missiles were responsible for most of the shootdowns of drones and cruise missiles in the April 2024 Iranian attack on Israel.[48] Advanced sensors in fifth-generation aircraft like the F-22 and F-35 fighters offer opportunities to collaborate with crewed fourth-generation aircraft or, in the future, CCAs to detect air and missile attacks and counter some inbound threats. Fifth-generation aircraft can share sensor data via datalink with other aircraft in flight, allowing for more efficient, effective engagements against inbound threats.[49] An integrated air defense command and control system can also sort, correlate, and share track data generated by airborne interceptors with ground-based interceptors.

Long-range surface-to-air missiles are costly and have limited availability. Long-range SAMs are important components of a layered air base defense system-of-systems. For the purposes of this paper, long-range SAMs engage threats beyond 30 nm (55 km). SAM systems like THAAD and Patriot Advance Capability-3 Missile System Enhancement (PAC-3 MSE), as well as the Navy's Standard Missiles (SM-2, SM-3, and SM-6), are some of the few SAMs that can effectively engage ballistic missiles and possibly even hypersonic

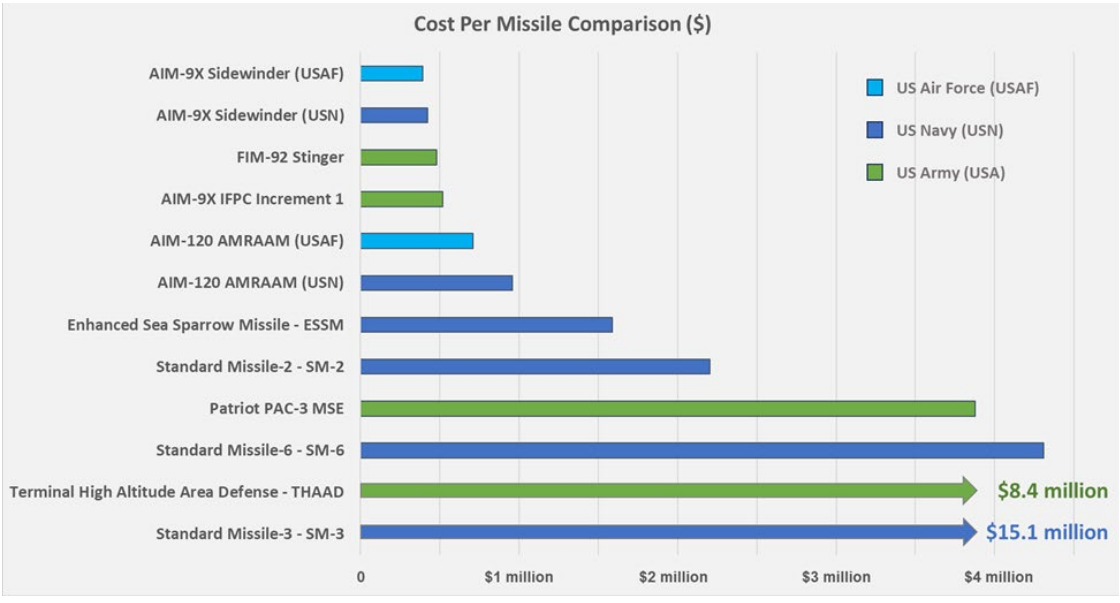

Figure 15: Cost per air-to-air and surface-to-air missile comparison in U.S. dollars.

Source: Mitchell Institute.

glide vehicles (HGV). Even then, maneuvering ballistic missile warheads or HGVs may challenge these advanced systems' hit-to-kill technology.[50]

The principal factor limiting the use of these long-range SAMs for air base defense is their cost and availability. A PAC-3 MSE is approximately $4 million per missile—ten times as much as an AIM-9X air-to-air missile and five times as much as an Advanced Medium-Range Air-to-Air Missile (AMRAAM). Systems that can potentially engage ballistic missiles outside of the atmosphere before they begin to maneuver include THAAD, at over $8 million per missile, and the SM-3, at over $15 million per missile. Figure 15 shows the cost comparison for different types of air defense missiles.

Higher costs combined with high operational demand for long-range interceptors will necessarily limit their availability for air base defense. An integrated, layered air base defense concept should realistically reserve these long-range, highly capable systems to engage only the most difficult-to-defeat enemy threats. Air base commanders and air defense operators will likely have to assume greater risks to reserve long-range SAMs for the most sophisticated threats and instead direct airborne interceptors as well as medium- and short-range air defense capabilities against inbound aircraft, cruise missiles, and drones.

Cost alone should not preclude the use of expensive surface-to-air missile systems for air base defense. A salvo of 20 Patriot missiles costs as much as a single F-35— a mere 1/20th the cost of a detachment of 20 aircraft—to say nothing of the lives of the air base personnel that the Patriot battery might be protecting. Weighing the cost of air defense missiles with the potential losses of inadequately defended aircraft, equipment, and personnel will be an important consideration in determining the right mix of passive and active defenses required for air base defense.

Need for lower-cost SAMs for air base defense. For the purposes of this paper, medium-range SAMs have sufficient range to engage inbound airborne threats within 25–30 nm (46 km), while short-range SAMs engage threats within 10 nm (18 km). The Army currently does not have a dedicated, fielded medium-range SAM. Medium-range engagements are instead left to the Army's Patriot SAMs. The soldier-portable or vehicle-mounted FIM-92 Stinger missile is a short-range, heat-seeking SAM with a maximum range of 2.5 nm (4.6 km). An effective air base defense will likely need new air defense systems that integrate more available and less costly shorter-range missiles instead of relying on long-range systems like Patriots for shorter-range intercepts.[51]

Since 2022, the Air Force has been evaluating low-cost, high-technology-readiness-level capabilities that could provide medium-range air base defense capacity in the near term. Air Force Research Laboratory (AFRL) analysis concluded that the National Advanced Surface-to-Air Missile System (NASAMS) may be a viable option.[52] NASAMS is self-contained and C-130 deployable, consisting of three components—a radar, fire control center, and canister launcher. NASAMS incorporates both medium- and short-range missiles, repurposing air-to-air AMRAAM and AIM-9X missiles in a surface-to-air role. AFRL also reportedly integrated NASAMS successfully with Air Force command and control systems.[53]

Maneuvering projectiles are promising new technologies. Maneuvering projectiles are a relatively new technology that may significantly reduce air defense engagement costs while increasing the rate of fire and kill rates against airborne threats.[54] These munitions are essentially "smart flak" that can guide themselves to inbound threats before exploding. They may be fired from existing artillery systems, cannons, or naval guns and are then command-guided to targets or, potentially,

self-guided to targets with an integrated seeker. Maneuvering projectiles as large as 155mm or as small as 30mm may provide cost-effective, short-range defense against aircraft, drones, and cruise missiles as part of an integrated, layered air defense system. These lower-cost, short-range weapons may also offer significant defensive capabilities and capacities to allies and partners.

Directed energy weapons and electronic warfare offer increased capacity at less cost. Directed energy weapons and electronic warfare capabilities may be able to defeat airborne threats at increasingly long ranges for a small fraction of the cost of kinetic weapons. High-energy laser (HEL) systems destroy targets through rapid heating created by focusing laser energy on air and missile threats. High-power microwave (HPM) weapons disable threats by interfering with or destroying electronics. Generating and focusing enough laser or microwave power on targets is the principal challenge for these systems.

Another challenge in operationalizing directed energy defenses is developing integrated systems with combat-relevant power levels that are small enough to be deployable. While DOD has not established standards for laser systems, a 100-kilowatt laser could engage UAVs, rockets, artillery, and mortars; a 300-kilowatt laser may be capable of engaging cruise missiles; and a 1-megawatt laser may be able to destroy ballistic missiles and hypersonic weapons.[55] The need to "dwell" a laser on a target may limit their effectiveness against hypersonic weapons that are designed to endure extremely high temperatures while in flight.

DOD intends to increase the power levels of potential HEL weapons to 300 kilowatts by 2024 and develop 500 kW class lasers with reduced size and weight by FY 2025. By FY 2026, DOD intends to reduce size and weight further and increase power to megawatt levels.[56] The Army is currently developing the Indirect Fire Protection Capability-High Energy Laser (IFPC-HEL) system that features a 300-kilowatt class laser.[57] The Army is also developing an HPM weapon system (IFPC-HPM) that may be effective against smaller UAVs that will work collaboratively with IFPC-HEL. The Air Force is developing the Counter-Electronic High-Power Microwave Extended-Range Air Base Defense (CHIMERA) system. Limited open-source information is available about CHIMERA or the types of targets it is intended to defeat.[58]

Determining the right mix of defenses

In the final analysis, generating combat-relevant sortie rates will require a combination of aircraft dispersal; passive defenses that include camouflage, deception, and hardening; repair and reconstitution capabilities; early warning; and layered, integrated active defenses that include a diverse combination of long-range and short-range capabilities. No one solution or defensive measure will ensure combat-relevant sortie generation rates under potential enemy attack. Determining the right mix of active and passive defenses to protect air bases, aircraft, and personnel will be an important task Air Force leadership must tackle in the coming years. Demonstrating Air Force confidence in those capabilities and the Air Force's ability to fight as an inside force will certainly have outsized deterrent effects against U.S. adversaries.

The Air Force has defined standards of performance for air base defense before. In December 1986, the Air Force published Regulation 360-1, *Air Base Operability Planning and Operations*. AFR 360-1 outlined the Air Base Operability program for how the Air Force would fight from its air bases. The regulation established planning factors for both active and passive air defense measures, as well as reconstitution and recovery capabilities.[59] The DAF's Operational Imperative 5 seeks

only to define the right mix of defenses, concealment, and hardening necessary to establish resilient air bases but does not lay out a plan to achieve those ends.[60] Beyond defining those standards, the Air Force must also identify the measures of performance and measures of effectiveness necessary to assess air base resilience.

In addition to defining requirements for forward air base training and logistics, OI-5 sets a goal to improve the Air Force's ability to generate sorties from distributed locations in combat conditions through the following measures:

- Enhancing infrastructure hardening and joint force-provided active defenses;
- Implementing the most cost-effective combination of investments to mitigate the threat to forward tactical air bases; and
- Engaging with willing allies and partners to provide access, basing, and overflight and build partner nation capabilities to defend air and space bases.[61]

The Air Force continues to pursue these Operational Imperative lines of effort. However, the scope and scale of enhancements and improvements apparently related to *Resilient Forward Basing* do not appear to address the evolving threat environment, especially in the Indo-Pacific. Despite the emphasis the Air Force has placed on the ACE concept and the urgency the service has attached to countering PLA threats, budgets for air base defense appear to be in decline. For instance, few, if any, hardening improvements to the Air Force's frontline Indo-Pacific bases are discernible. The Air Force continues to grapple with a chronic lack of resources, which continues to degrade readiness and slow the pace of force recapitalization and modernization programs.

Given the broad set of efforts within the *Resilient Forward Basing* initiative, it is difficult to discern the specific funding that contributes to the imperative's outcomes. Half of FY 2024 funding related to OI-5 probably relates to "Military Construction and Pacific Resilient Distributed Air Basing"—$667 million within the FY 2024 Pacific Deterrence Initiative.[62] That budget request earmarked funding for basic infrastructure improvements to air bases in Guam and northern Australia but did not appear to fund much-needed passive defense capabilities like hardened aircraft shelters for frontline bases in Japan or the Philippines. While OI-5 may inform how the Air Force spends funds across its programs, achieving the type of resilience envisioned by the initiative will undoubtedly require focused effort and funding specifically allocated to achieve *Resilient Forward Basing* outcomes.

Conclusions

Solutions are immediately required to address critical shortfalls in active air defense capabilities, passive defenses, and air base reconstitution capabilities in multiple regions. The war in Ukraine and the growing potential for a conflict in East Asia with China's PLA only serve to highlight the need to address these consequential deficiencies. The Air Force's Pacific air bases, in particular, face significant threats from PLA long-range fires that are enabled by dense, layered ISR capabilities. The PLA will attempt to create synergies and overwhelm active and passive defenses by employing several types of weapons in synchronized attacks on air bases. These threats from the PLA's arsenal of long-range precision strike weapons are serious but not necessarily impossible to overcome. U.S. and allied air bases in the Indo-Pacific, especially along the First Island Chain, must be prepared with a diverse set of active and passive air defenses arrayed against these potentially diverse and complex attack threats.

The U.S. Air Force must remain capable of fighting its air bases and operating forward alongside important

U.S. allies and partners. To do so, it must continue its efforts to define the best mix of integrated air base defense capabilities that will ensure it remains an inside force capable of generating combat power while operating within adversary air and missile threat envelopes. Measures should include the ability to disperse Air Force combat aircraft as envisioned by the ACE concept, combined with effective active and passive air defenses and base recovery and reconstitution capabilities. These defenses will ensure the Air Force is capable of generating sorties at combat-relevant rates, even under sustained enemy fire.

Despite these urgent requirements, the current congressional budget caps on the DOD budget are severely hampering the Air Force's funding for "optimized resilient forward basing." It appears that the Fiscal Year 2025 request for these critical requirements is half of the request in the Fiscal Year 2024 budget, reducing funding for "resilient basing" from $1.3 billion to $600 million.[63] These trends are arguably going in the wrong direction.

Demonstrable progress toward actually hardening and acquiring defenses for forward air bases in the Indo-Pacific does not appear to match the pace of the growing threat. Budget requests appear to focus on basic infrastructure improvements at rear bases, which are complemented by a small number of logistics and air base damage control capabilities. The Air Force seems to be on a path similar to the one it walked nearly 30 years ago when it abandoned the Air Base Operability program at the end of the Cold War due to budget concerns. DOD's focus on short-range ground-based air defense programs to counter tactical UAVs as well as rockets, artillery, and mortars reflects the well-worn saying that the U.S. military is "always preparing to fight the last war." Countering Houthi drones attacking shipping in the Red Sea or countering insurgent attacks on isolated U.S. outposts in Southwest Asia is an important mission, but these tactical challenges also serve to anchor U.S. military thinking in the last war instead of considering how a large-scale conflict with the PLA might unfold in East Asia.

Recommendations

This report proposes an operational concept for air base defense built around three core elements: 1) air base and aircraft dispersal envisioned by the ACE concept; 2) a diverse, layered arsenal of active defenses that includes kinetic and non-kinetic effectors to provide cost-effective protection against incoming attacks; and 3) passive defenses that include early warning and threat tracking, as well as hardening and substantial reconstitution capabilities, especially rapid runway repair.

To realize the proposed air base defense operational concept, correct air base defense deficiencies, and address critical shortfalls in active and passive defenses, Congress, DOD, and the Air Force should consider the following recommendations:

- **Continue to develop, codify, and implement the ACE concept.** Air base defense is a core feature of the ACE concept. ACE alters Air Force posture in theater and disperses operational forces, a key element of passive air defense for frontline air bases. The Air Force should define standards for *Resilient Forward Basing* to guide future active and passive air defense investments and budget requests. The Air Force must also identify the measures of performance and measures of effectiveness necessary to assess air base resilience.
- **Remove or significantly modify defense budget caps to fund a dedicated air base defense program.** In the face of significantly increasing adversary threats, budgets to enable ACE and provide for

air base defense cannot simply be carved out of existing budgets. There is a need for additional funding to address necessary operational requirements for the defense of U.S. air bases and other crucial theater targets. Congress and DOD should offer oversight to hold the military services (including the Air Force) accountable for defining their specific requirements for air base defense capabilities and infrastructure. Congress must, however, fund air base defense capabilities at levels commensurate with the value that air power offers to theater operational plans, the strength to alliances and partnerships, and the contributions to deterrence against would-be adversaries.

- **Reestablish inter-service agreements on air base defense.** Unless the Air Force is manned, trained, and equipped to provide its own ground-based air defense, the Air Force will have to rely on its service partners for these capabilities. Service air defense capabilities should align with the foreseeable operational air defense requirements of the theater air component commander, who will ultimately become the Joint Force Air Component Commander in a conflict. The 1980s saw the Air Force establish an MOU with the Army that secured a commitment to meet requirements to fund, equip, and man ground-based air defenses for Air Force bases. This should be the starting point for a future agreement. The Army and, in littoral regions, the Navy should provide theater-wide, high-altitude air defense and ballistic missile defense. In proximity to air bases, the Army should provide intermediate- and short-range ground-based air defenses. If such an agreement proves impossible or impractical, Congress should consider directing resources to the Air Force to provide its own fundamental air base defense capabilities.
- **Fund, build, and deploy substantial passive air base defenses.** The Air Force should receive substantial funding for passive defenses, *the* most cost-effective measures against air and missile attack, which drive up adversary costs and create tangible deterrent effects. Passive defense measures include hardening indispensable air base facilities and the construction of hardened aircraft shelters. Camouflage, concealment, and deception capabilities, ranging from simple measures such as overhead shelters to the use of physical and electronic decoys, are also essential to causing an adversary to potentially waste its weapons on false instead of actual targets.
- **Invest in rapid runway repair and air base reconstitution capabilities.** Categorized as a passive defense measure, rapid runway repair is a capability necessary to return main or dispersal air bases to operational status. Sustained adversary attacks on runways threaten to close air bases for extended periods and effectively suppress combat sortie generation. Multi-capable Air Force airmen should be cross-trained in rapid runway repair capabilities. Other important reconstitution capabilities include explosive ordnance disposal, on-site medical services, and alternate means for refueling aircraft.
- **Invest in space and airborne early warning as well as long-range airborne kinetic and non-kinetic capabilities for air base defense.** Also categorized as a passive defense measure, an effective air base defense operational concept requires early warning of low-flying inbound threats such as HGVs, cruise missiles, and drones. Early warning provides advantages for surface-to-air defenses as well as non-kinetic electronic attack or directed energy weapons. It may allow for passive defense measures such as quickly sheltering

aircraft or closing blast doors. Combining early warning with an airborne air-to-air engagement capability would create an outer ring of long-range defenses against inbound weapons targeting air bases.

- **Significantly increase investments in cost-effective air base air defense sensor and C2 capabilities, potentially by leveraging existing systems.** Detecting inbound threats and coordinating effective responses to attacks is a decisive component of an effective air base defense operational concept. Engaging all threats at the longest ranges with scarce, expensive effectors will quickly deplete defensive weapons in the face of sustained enemy attacks. Air defenses must have a redundant and survivable sensor and C2 capability to economically and effectively allocate the right defensive capabilities and weapons at the appropriate ranges to ensure defense against sustained enemy attacks. Many of these systems exist as programs of record across the different services: for example, the U.S. Army's Sentinel A4 air defense radar.
- **Significantly increase investments in a diverse arsenal of integrated active defense capabilities, especially cost-effective short-range defenses.** The Air Force and the Army, especially, must invest in a diverse set of ground-based air defenses, including intermediate-range surface-to-air missiles and a host of short-range capabilities that include missiles, air defense cannons with maneuverable projectiles, directed energy weapons, and electronic warfare capabilities. A mix of cost-effective kinetic and non-kinetic capabilities should be organized in a dense terminal kill web with necessary air defense sensors and C2. Ideally, active defenses will include a greater diversity of capabilities to mitigate the threat of adversary countermeasures against what are currently relatively homogenous air defense interceptors.
- **Pursue additional studies, modeling, experimentation, and air base defense exercises.** Through additional study, high-fidelity modeling, and real-world experimentation, the Air Force can determine the most capable, cost-effective mix of passive defenses and kinetic and non-kinetic air defense. Considerations for future examination should extend beyond aircraft survivability and combat sortie generation to include reconstitution of other important base functions and human factors, such as projected personnel losses and requirements for air base medical capabilities. Additionally, the Air Force should study and consider requirements for integrated active and passive air base defenses to protect Air Force bases in Alaska, Hawaii, and the West Coast of the United States against future PRC threats.

The first issue of the Air University's *Airpower Journal*, published in 1987, featured an article, "Fighting from the Air Base," that is as applicable today as it was during the Cold War:

> *As this review shows, rather than trying to beat us in the air, the Soviets think that the key to defeating our Air Force is to take the fight to our air bases and other theater installations. By preventing us from generating large numbers of timely and effective sorties, they will ensure that we have little opportunity to use our superior training and technology to fight in the air. It is because of this possibility's immense dangers that we must reassess our current capability to fight from the air base, specifically to defend the base while continuing flying operations despite enemy attacks.*[64]

Regrettably, 37 years later, the article is a reminder that the Air Force must re-learn how to fight its air bases. More than that, this is not solely the Air Force's problem to solve. DOD and Congress must support the Air Force in responding to this call to action. The Air Force and its joint partners must prioritize air base defense as the make-or-break component of the joint warfighting construct that it is.

Expanding air base defense capabilities and capacities will take time, which demands we begin the process now. One could go even farther back in history to the years immediately prior to World War II when leaders saw the looming threat from Axis powers but struggled to garner support to prepare. As Secretary of War Harry Woodring explained to President Roosevelt in 1938, "We are not prepared for conflict. Billions appropriated today cannot be converted into preparedness tomorrow."[65]

Fighting from well-defended front-line air bases may mean the difference between winning and losing in a future conflict. If the Air Force cannot defend its bases and operate forward to fight alongside allies and partners, it calls into question the ability of the United States to deter and dissuade its would-be adversaries. The U.S. and allied way of war demands a capable Air Force that can operate inside adversary threat envelopes. Making necessary investments in capable, cost-effective, and combat-relevant air base defenses is vital to U.S. national security. ✪

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