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Basing Strategies for Air Refueling Forces in Antiaccess/Area-Denial Environments

Robert C. Owen



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ROBERT C. OWEN

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About the Author

Robert C. Owen is a professor in the Department of Aeronautical Science at Embry-Riddle Aeronautical University, Daytona Beach campus. In this position, he teaches courses in manned and unmanned aviation operations, law, and history and conducts research in national defense policy issues. Professor Owen joined the Embry-Riddle faculty in 2002, following a 28-year career with the United States Air Force. His military career included a mix of operational, staff, and advanced education assignments. He is both an Air Force command pilot and a commercial pilot, with instrument and multi-engine ratings. He flew over 3,400 hours in the Air Force and over 1,000 hours in various civilian aircraft. Professor Owen also served on the Headquarters Air Force staff and the Headquarters Air Mobility Command staff. His academic assignments included tours as an assistant professor of history at the US Air Force Academy and as dean of the USAF's School of Advanced Airpower Studies (now the School of Advanced Air and Space Studies), the service's graduate school for strategic planners. In addition to numerous articles and monographs, his book publications include the chronology volume of the *Gulf War Air Power Survey* (1995), *Deliberate Force: A Case Study in Effective Air Campaigning* (2000), and *Air Mobility: A Brief History of the American Experience* (2013).

Abstract

This study addresses the challenge of basing air refueling forces in regions marked by scarcities of appropriate airfields and powerful antiaccess/area-denial (A2/AD) threats from regional enemies. In such conflicts, the scale of required tanker deployments likely will overwhelm the number of first-class airfields available to accommodate the airliner-based air refueling aircraft in the United States Air Force fleet. Moreover, tankers based in forward areas will be subject to a wide range of enemy attacks on the ground and in the air. Consequently, this study begins by discussing the nature of the threats posed to forward-based air refueling units by modern A2/AD systems and then examines various basing concepts to mitigate those threats. The basing concepts explored are hardening of aircraft shelters and support facilities, disaggregation of refueling units among prepared bases, and agile disaggregation among more austere base infrastructures. The study also includes discussion of the potential value of introducing a midsized “tactical” tanker to the fleet able to operate from airfields substantially shorter and more weakly surfaced than those required by the current fleet of modified airliners. The study concludes by recommending greater focus on agile disaggregation, acquisition of a fleet segment of tactical tankers, and directions for further analysis.

Introduction

The increasing threat to American air refueling forces from sophisticated antiaccess/area-denial (A2/AD) capabilities in the hands of potential enemies has become a matter of concern for defense planners and leaders.¹ An important product of this concern has been an active discussion of the challenge of operating air refueling forces from forward bases under potential or actual attack. Generally, this discussion has explored three forward basing concepts; hardened, disaggregated, and agile. Hardened bases employ reinforced sheltering of aircraft and support facilities to increase their resilience under attack. Disaggregation complicates enemy targeting efforts by operating forces from many smaller bases rather than just a few large ones. Agile basing protects forces by frequently shifting them among a number of bases, thereby “improving survivability and complicating the enemy’s targeting.”²

Given these considerations, this study encapsulates the present state of the discussion over tanker basing and asks whether an updated US strategy should emphasize hardened, disaggregated, or agile concepts. The study begins with a qualitative discussion of the threat posed to air refueling forces by a representative A2/AD system—that of China. It next discusses the operational and logistical characteristics of each basing option, paying particular attention to its ability to underpin the resilience and maximal effectiveness of tanker forces under A2/AD threat. This comparative discussion closes with a brief examination of aircraft options to exploit the strengths and/or mitigate the weaknesses of each basing concept. The study concludes with recommendations for further action by the Air Force and the Department of Defense (DOD).

The Threat

If good sense and luck prevail, the United States and China will never find themselves at war. However, there is no escaping the fact that the increasing power of Chinese A2/AD capabilities and the geography of the western Pacific make China a worst-case challenge for tanker basing strategies. Its forces can hit US air bases hard, and alternative airfields are relatively scarce and widely separated. Consequently, basing strategies that could work in the western Pacific in the face of Chinese capabilities likely could work in many other regions.

China’s A2/AD order of battle is formidable. It begins with overlapping ground-, air-, and space-based information, surveillance, and reconnaissance (ISR) systems, including around 100 satellites of various capabilities.³ The bulk of China’s long-range, non-nuclear strike capabilities reside in the 1,900 or so combat aircraft of the People’s Liberation Army Air Force (PLAAF),

supplemented by missile forces. China's air fleet includes about 150 H-6 bombers, some of which can strike out to approximately 2,000 nautical miles (nm) when equipped with cruise missiles. China's missile forces include over a thousand short-range ballistic missiles (SRBM), hundreds of cruise missiles, and a "limited but growing" fleet of DF-21C and D medium-range ballistic missiles (MRBM).⁴ In combination, these systems can conduct precision-guided strikes against all major US bases in Korea, Japan, the so-called first island chain, and—mainly with cruise missiles—the second island chain.⁵ Additionally, the Chinese navy fields a growing number of surface and sub-surface combatants capable of launching land-attack and antishipping cruise missiles. Last, US bases anywhere in the western Pacific could face attacks from Chinese special operations forces (SOF) and fifth-column actions from elements of the millions of ethnic and recent-migrant Chinese nationals present in every Asia-Pacific country.⁶

Formidable as the Chinese battle array has become, it is important for tanker basing planners to recognize that its power degrades rapidly as the distances between China's bases and targets increase (fig. 1). China's ability to launch the concentrated, all-capabilities "gorilla strikes" called for in its military doctrines is limited to about 400 miles from its launch bases.⁷ This distance equates roughly to the range of weapons-laden fighter aircraft, which would constitute the bulk of China's strike capabilities in this "gorilla ring," augmented by SRBMs.⁸ Beyond the gorilla ring is the "missile ring," a zone extending 400–1,000 nm from Chinese bases in which long-range missiles augmented by limited numbers of strike aircraft would provide the weight of their offensive capabilities. While a few hundred missiles represent a real threat to US assets in the missile ring, they would not carry the weight and persistence of the hundreds of aircraft and short-range missiles in the gorilla ring. Beyond the missile ring would be what could be called the "maritime ring." The threat array in this region would be a relatively thin arsenal of bombers utilizing China's limited aerial refueling capabilities and cruise missiles launched by submarines and surface combatants.

Despite the different threat levels presented within the gorilla and missile rings, most unclassified defense analyses have not differentiated among the survivability of large aircraft based within them. Regardless of the differing weights of potential attacks and of US base defenses, many conclude that persistent, multilayered air and missile attacks will penetrate these rings.⁹ Large tanker aircraft and their extensive maintenance and logistics support infrastructures would be particularly vulnerable to such penetrations. Consequently, most interested analysts and commanders agree that US tankers and

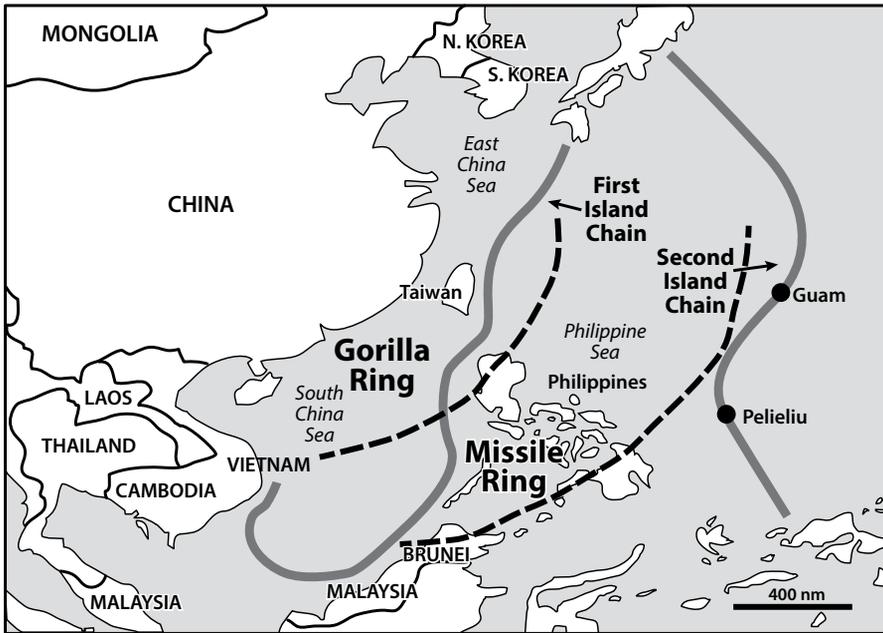


Figure 1. Relationship of island chains and threat rings. (Adapted from Department of Defense, *Military Power of the People's Republic of China*, 2006 [Washington, DC: DOD, 2006], 15, with addition of threat rings by author.)

other large aircraft “should be operated from bases out of the range of China’s conventional ballistic missiles.”¹⁰ In other words, they imply that American air commanders must abandon the first 1,000 miles or so of available tanker bases to preserve their air refueling forces, regardless of the negative impact such a retreat would have on their effectiveness.

Several aspects of Chinese military circumstances suggest, however, that completely surrendering operations from within the missile ring may not be necessary. Most importantly, the Chinese military is not organized, experienced, or culturally constituted to conduct joint warfare in a fast-paced conflict in the face of enemies who are.¹¹ Moreover, the efforts of senior commanders to speed up their decision processes and to articulate their forces with greater agility have been, and likely will continue to be, undermined by economic, social, and political circumstances beyond their control.¹²

Of nearly equal importance, the political and military considerations of long-range missile operations likely will accentuate the innate caution and slowness of Chinese military command and control. Expending MRBMs and

cruise missiles from limited magazines will be national decisions since doing so will deplete an important strategic military and political deterrent and reduce the number of weapons available for other missions. If nothing else, Chinese leaders will demand a high degree of certainty as to the importance and exact locations of the targets against which they release their precious “silver bullets.” Unfortunately for them, China’s ISR capabilities do not have the persistence of coverage and fidelity to keep elusive and shifting tactical targets located with consistency, particularly if the decisions to release them come hours after those targets were last detected. Worse, for potential attackers, all of the terminal guidance systems utilized by long-range precision weapon systems—navigation satellites, radar, infrared, electro-optical, laser cueing, and so on—are subject to shutdown, jamming, blinding, spoofing, and other forms of defeat or degradation by defender actions.

In net, these operational considerations regarding uncertainty and the technological limitations of precision weapons suggest the possibility of operating air refueling bases with resilience in the missile rings of future enemies. In those rings, US operations can impose great uncertainty on enemy command systems by degrading the fidelity and velocity of their ISR and command, control, and communications systems and by protecting forces through sheltering, deceptive basing, and/or maneuvering them faster than they can be tracked. These actions would increase and exploit the inescapable reluctance of enemy commanders to take shots at uncertain targets with weapons that are in short supply and that must be husbanded in consideration of broader strategic concerns.

Assessing Basing Options

Hardened, disaggregated, and agile basing are options in the context of resilient operations within the missile rings of China or other possible opponents possessing robust A2/AD capabilities. In discussing the operational and logistical features of these concepts, this analysis focuses on the contributions each would make to force resilience and productivity. More specifically, it assesses each basing mode’s ability to sow confusion within enemy command structures, protect forces when discovered, sustain maximal effectiveness, continue operations despite attacks, and be supportable logistically.

Hardened Bases

In of itself, hardening bases will improve the resilience of air refueling forces only marginally. Indeed, shelters may reduce enemy uncertainty by marking the most important targets on a base. All of those shelters will be

vulnerable to penetration by large unitary warheads and specialized submunitions. Even shelters built to withstand direct hits by 2,000-pound-class warheads would be vulnerable. Faced by the armored doors and 20-foot-thick earth and reinforced concrete carapaces of such shelters, potential enemies could still defeat them by employing larger weapons, punching through them with sequential warheads, or destroying the logistical or ground-maneuvering infrastructures (taxiways and runways) needed to utilize the assets they protect.¹³ Fixed, hardened facilities, in short, will be vulnerable to attack by aircraft penetrating their base defenses and to long-range missile sniping.

Shelters can only be useful, therefore, as elements of layered defensive systems. If protected by overlapping shields of cyber and electronic warfare capabilities, effective counterair and missile defenses, and the degradation of enemy capabilities by ongoing US and allied offensive operations, hardening can increase the costs of attacking tankers beyond what enemy commanders may be willing to pay. Even a defensive shield that deflected or destroyed only 50 percent of inbound missiles, for example, would oblige enemy commanders to shoot several missiles for every shelter they wanted to hit. They would have to account for both the reduced probability of penetration and the reality that many warheads would strike outside of their nominal average impact accuracies or circular error probable. Enemy commanders might be reluctant to expend so many scarce weapons against those targets, given the existence of higher-priority concerns such as carrier battle groups and the need to preserve their missile magazines as hedges against military or political surprises.

Hardening presents a mix of desirable and troubling logistical and operational impacts. Logistically, base hardening can preserve support systems and organizations working at maximal efficiency. But if enemy forces break through base defenses, hardening will provide them with their best aimpoints. Also, based on the limited unclassified information available, it is reasonable to estimate that a large aircraft shelter will cost from \$20 to \$40 million to construct at overseas locations, depending on the level of protection desired.¹⁴ So to equip a single base with enough shelters to house, say, 16 tankers that spend 50 percent of their time in the air will require construction of at least eight primary and probably a few hedge shelters at a potential cost of several hundred million dollars. Building a network of hardened bases along the Pacific Rim, for instance, would cost billions and provide protection only for operations in their areas and only so long as even more costly defensive networks successfully fend off the bulk of enemy attacks.

Moreover, hardened bases offer minimal ability to support offensive and defensive operational surges. Separated by hundreds and even thousands of miles from other bases in the hardened network, no single base could shelter

the tanker force concentrations needed to support surge operations or render efficient mutual support to distant locations. Perhaps the best way to understand the value of hardened basing, therefore, would be as a premium method of sheltering those portions of future tanker fleets that absolutely must be based in a particular region all of the time and as far forward as possible, with other basing modes providing surge support when required.

Disaggregated

Disaggregation's effect on resiliency will depend on how and where it is done. In theory, the DOD expects that disaggregating aircraft and support resources will result in "decreasing vulnerability through redundancy and complicating the enemy's targeting efforts."¹⁵ But if units are merely scattered among the unprotected parking areas of several military or civil airfields, the promise of decreased vulnerability will be empty. If such "fixed-base" disaggregation is attempted within the gorilla ring, enemies equipped with capable ISR and strike forces will locate and attack those units quickly and almost certainly with devastating results. Even in the missile ring, disaggregation would do little to protect air refueling units operating at fixed locations longer than the detect-target-strike cycles of their enemies. Further, today's aerial refueling fleet aircraft dimensions and weight-bearing effects on base surfaces already limit and could overwhelm the available basing outside the gorilla ring. Ultimately, the current US fleet will have no place to disaggregate if the bases available to receive aircraft in the current fleet are already saturated.

The logistics of providing for redundant bases comprise the greatest challenges to the ability of disaggregation to sustain air refueling forces at maximal productivity. Dispersing logistics and support echelons among several bases will oblige the Air Force to acquire redundant supplies and equipment and, quite likely, increase manpower allocations to provide specialist technician coverage at all locations. Connecting subunits by air or surface lift could reduce those redundancies. But doing so will increase the pressure on overtaxed transportation assets and commanders waiting for the arrival of key supply items and pooled specialists to get broken aircraft back into service. Similarly, unit moves, particularly by airlift or road marches, likely will interrupt the operations and efficiency levels of disaggregated units for hours or even days. Little wonder that, even as it considers the advantages of disaggregation, the DOD worries that it "could be logistically unsupportable . . . [since it] imposes a logistical burden, but . . . offers no direct remedies other than improved efficiency."¹⁶

Disaggregated units also will face significant and sometimes unique operational risks. Among them will be the security risks incumbent in the warehousing, local support contracts, and host nation access arrangements needed to prepare airfields for disaggregated operations. All of these actions will be impossible to hide and, in all likelihood, will enable potential enemies to develop air and ground attack folders on every disaggregation base long before any shots are fired. Disaggregated units also will be dependent on long-range Web, telephone, and radio communications to stay in touch with their chains of command and even to perform mundane logistics functions. All of these systems are vulnerable to enemy detection, intrusion, jamming, and spoofing operations. Separated from their chains of command, junior commanders at disaggregated bases also may be overwhelmed by local challenges ranging from base security breaches and supply shortages to the presence of enemy nationals on their airfields and disputes with local civil and military leaders.

Agile

Agile basing offers opportunities to mitigate the shortfalls inherent in disaggregated and hardened basing. This particularly would be true if the Air Force could employ this concept in a manner that truly got “inside” enemy detect-target-strike cycles. Doing so likely would require a concept characterized by *agile disaggregation* and *dynamic dispersal*. Agile disaggregation would involve dispersing tanker forces in small units among sets of civil and/or military airfields and moving at least some of those penny-packet units to other bases every day or so. Dynamic dispersal would involve frequent, probably hourly, movement of the aircraft and some or all of the key assets located on each operating airfield. In net, a truly agile basing concept would be a shell game in which the shells (bases) and the peas (aircraft and assets) would shift locations constantly and unpredictably.

This combination of agility and dispersal would infuse great uncertainty in the weapons release decisions of enemy commanders. They would never be sure that their precious and finite resources of long-range missiles and aircraft strike assets would find their intended targets where they were last observed. Decisions regarding MRBM releases would be particularly affected since data just an hour or so old would create a possibility that their warheads would hit empty dirt rather than targets of value. Additionally, if the tanker aircraft on those airfields could utilize their unpaved margins and other areas for parking, they could be dispersed far enough apart to preclude any single unitary warhead or even cluster or other area warheads from hitting more than one aircraft at a time, if they hit anything.

Anyone familiar with the logistic, operational, and command and control elements of air refueling operations will immediately see the challenges to achieving their agile disaggregation and dynamic dispersal. The most daunting logistical challenge will be satisfying the huge fuel requirements of air refueling units. A disaggregated expeditionary unit of six KC-46s flying three maximum offload sorties per day, for instance, would consume about 620,000 gallons of fuel daily. Thus, disaggregated units must be on or near airfields equipped with permanent high-volume storage and distribution systems or expeditionary fuels systems of equivalent capacities. Moving self-supporting units between airfields also can degrade their operational efficiency, increase personnel fatigue, disrupt communications linkages, challenge the situational awareness of senior commanders and staffs, and have a host of other impacts on unit productivity. Whatever the operational promise of agile basing, its logistics and human characteristics can seem daunting. Fortunately, there are good reasons to think that the concept could work.

The historical record provides many examples of agile basing of large, land-based aircraft, usually in conjunction with sea-based support in maritime environments. From the earliest days of naval aviation, the Navy used seaplane tenders to support bombing and patrol operations. During World War II, the Army Air Forces' Project Ivory Soap employed a fleet of ships to provide logistics, maintenance, and other base services for B-29 and P-51 groups in the Pacific campaigns.¹⁷ On a smaller scale, the Navy successfully operated converted landing ship tanks from 1957 to 1970—the USS *Alameda County* (AVB-1) and USS *Tallahatchie County* (AVB-2)—to support patrol bombers and other aircraft at ashore bases in the Mediterranean. Presently, the Maritime Administration's Ready Reserve Fleet includes two much larger advanced base-support ships for the US Marine Corps—the USS *Wright* (T-AVB-3) and USS *Curtis* (T-AVB-4).¹⁸ The Marines exercise these ships frequently and successfully in support of all types of aviation units, including KC-130s.¹⁹

The common element of sea basing in all of these historical examples made sense at the time and offers grist for thought about the future. They suggest that sea-supported basing of tanker units can maximize the agility, productivity, and resilience of ashore tanker units. By housing most of the command, logistics, medical, and other support elements of disaggregated tanker units in an organized and climate-controlled environment, a ship base could decrease the disruption, fatigue, and productivity impacts of shifting ashore units frequently. This strategy would minimize the operational impacts and transportation costs of relocating supported units since only minimum essential personnel and materiel would operate ashore. For example, the USS *Tallahatchie County* could disembark the *entire* shore establishment required

by a PV-2 Neptune squadron (9–10 aircraft, about 200 personnel, a dozen vehicles, and 19 large trailers) and have it in operation in just four hours. Packing up and reembarking the unit took about the same amount of time.²⁰ Connected to their base ship by amphibious craft and helicopters, sea-supported tanker units also would reduce supply and specialist personnel redundancies by drawing their support from common pools on the ship. General resilience would be improved by the absence of any need to pre-position supplies and establish location-specific access and support contracts at any airfields utilized eventually for agile sea basing. It would also be enhanced by the ability of the ship's landing craft and helicopter "connectors" to support disaggregated airfields operating within a radius of around 200 nm.²¹

Further, modern expeditionary and amphibious warfare systems reinforce the practicality of sea basing air refueling assets. A new or reconditioned amphibious warfare ship, for example, could house the necessary support elements. It also could carry the amphibious craft and helicopters needed to disembark, reembark, and sustain onshore units. Importantly, an amphibious warfare ship could carry the expeditionary fuel-handling and storage-equipment sets and their set-up personnel critical to sustaining the maximal effectiveness and agility of the air units. For example, a single combination of an amphibious assault bulk fuel system (AABFS) to link an offshore tanker ship to an airfield and the tactical airfield fuel dispensing system (TAFDS) to put the fuel on the planes could satisfy the 620,000-gallons-per-day fuel requirement of the KC-46 force already discussed.²² Both of these systems can be set up by two small teams of specialists and begin filling in about six hours.²³ Moving these fueling systems among bases can take longer, particularly if the fuel storage bladders of the TAFDS must be drained and repacked. But delays could be reduced by establishing relatively inexpensive bladder sets at several bases and leapfrogging the pumping hardware and support teams between them.

Marrying the agile basing concept with the right aircraft also can improve resiliency and productivity. In theory, any aircraft can be agile-based. However, airliner-derived refueling aircraft, such as the Boeing KC-46A and the Airbus A330 multirole transport tanker (MRTT), require sea-level runways of 8,000 to 10,000 feet in length to operate safely at their full gross weights. Given the limited numbers of such runways in many regions of the world, this requirement could restrict the ability of these aircraft to disaggregate with enough unpredictability to confuse enemy commanders as to where they might be or go next. In contrast, military tactical transport-derived air refuelers, presently the Lockheed KC-130J and Airbus A400M, can operate at full gross weight from sea-level runways of 4,000 to 5,000 feet in length. Moreover, they can be towed across and taxi or park on unpaved surfaces equivalent to

saturated clay soils. As a consequence, they can practice dynamic dispersal with a vengeance, moving frequently between maximally dispersed locations. If the maximal agile disaggregation and dynamic dispersal of these aircraft equates to greater resilience in forward locations (and it does), then it also equates to greater productivity. These transport tankers are less capacious than airliner designs, but being able to base forward and survive would greatly improve their net offloads to receiver aircraft.

Last, an agile-based ship should have an acceptable chance of surviving—at least in the missile ring. As would other Navy ships operating in that threat environment, it would preserve itself through a combination of maneuver, deception, terrain and shallow-water masking, electronic warfare, close-in weapons, and other defenses. The base ship would move constantly, using busy shipping areas and geographic features to mask it from detection and strike by space systems, over-the-horizon radars, aircraft, missiles, and submarines. It would stop only periodically and for an hour or so to disembark and reembark airfield teams and equipment. Equipped with the sensors and close-in defensive weaponry typical of any amphibious warfare ship, a base ship would have a good chance of defeating or diverting the guidance sensors of bombs, missiles, and torpedoes and of fending off small boat attacks. These systems also could defeat manned or unmanned aircraft and surface craft maneuvering into position to provide guidance cueing for enemy weapon systems. Of course, the base ship would be defending itself as an element of integrated air and naval operations aimed at degrading an enemy's general offensive capabilities. In sum, an agile-base support ship would face risks common to other ships in the area, but it would not be a sitting duck or doomed to sinking at the onset of operations.

Aircraft

To differing degrees, the effectiveness of each of the basing concepts under consideration will reflect the operational characteristics of the aircraft matched to it. The salient operational characteristics of air refueling aircraft are their range/offload curves—how much fuel they can deliver to receivers at what distances from their bases. Given the scope of the basing concepts under consideration, however, it will be important to consider other aircraft features, such as the length and strength of the runways and other infrastructure they need and their secondary airlift capacities. The weight-bearing requirements of a given aircraft will constrain the number of airfields it can utilize in a given region, its ability to operate from damaged airfields, and its capacity to utilize unpaved areas for taxi and dispersed parking. The airlift capacities of air refueling aircraft affect

their ability to contribute to the mobility of their own units and to augment general airlift efforts when their air refueling capabilities are not needed.

Realistically, only three tanker aircraft are currently suitable for consideration in a basing analysis. The first two—the Boeing KC-46A and the Lockheed KC-130J—already comprise the core air refueling modernization programs of the Air Force and the Marines, respectively. The third in-service aircraft available is the Airbus Industries A400M. This aircraft falls between the KC-46A and KC-130J in size and range/offload characteristics. Like the KC-130J, the A400 has probe-and-drogue refueling capability only. But, given the high percentage of sorties that US Navy and Marine aircraft would fly in maritime or littoral campaigns, probe-and-drogue refuelers would (and do) make valuable contributions to overall refueling efforts. As a valuable byproduct, their use also frees the boom-equipped fleet to focus on servicing Air Force aircraft. All other air refueling aircraft designs available are either too old or limited in numbers to be reasonable candidates for forward basing (the Boeing KC-135R and McDonnell-Douglas KC-10A) or are designs that offer or would offer only marginal advantages over aircraft presently in the fleet (the Airbus A330 MRTT and the developmental Embraer KC-390). Any proposals to develop other aircraft for air refueling operations almost certainly would fail in the context of the penurious budgetary circumstances of the current US defense program. Consequently, it is useful here to encapsulate the comparative assets of the three candidate aircraft (table).

Table. Fuel offload capacity at varying operational radii (pounds x 1,000)

<i>Radius of action (nm)</i>	0	500	750	1,000	1,250	1,750	<i>Operation on unsurfaced areas?</i>	<i>Cargo hold size L/W/H in feet</i>
C- 130J ^a	82	51	44	36	28	12	Y	40/10/9
A-400M ^b	138	89	77	66	55	32	Y	58/13/13
KC-46A ^c	207	155	144	134	122	110	N	111/16/9 ^d

(Presumes round-trip transit, two hours on station, and one hour reserve fuel.)

^aBased on C-130J air refueling performance data provided by Headquarters Marine Corps Aviation Division/APP-5 (Plans, Concepts and Integration), to the author, e-mail, 13 June 2014. Basic presumptions are 83K pounds of transferable fuel (tanker configuration), a 5K/hour burn rate, and 320-knot true airspeed cruise.

^bBased on extrapolations of data provided in EADS North America briefings: “All A400Ms Are Tanker and Receiver Capable,” 2014; and “A400M: Combat Delivery to Point of Need,” 2013. Basic presumptions are 9.0K/pounds/hour fuel burn rate and a 400-knot cruise.

^cGiven the public unavailability of nonproprietary information on the KC-46’s expected range/offload characteristics, this data is a product of integration and interpretation of data from several sources including Boeing, “767 Airplane Characteristics for Airport Planning,” September 2005, <http://www.boeing.com/assets/pdf/commercial/airports/acaps/767.pdf>; Air Force Pamphlet 10-1403, *Air Mobility Planning Factors*, 12 December 2011, http://static.e-publishing.af.mil/production/1/af_a3_5/publication/afpam10-1403/afpam10-1403.pdf; and “Boeing 767-300ER,” in *Jane’s All the World’s Aircraft 2012–13*, ed. Paul Jackson (London: HIS Global, 2012), 998. These data, therefore, are reasonably accurate but not definitive. Basic presumptions: 207K pounds of transferable fuel, 10K/pounds/hour burn rate, and 460-knot cruise.

^dIn contrast to the rectangular cross sections of the C-130 and A400M, that of the KC-46 is the upper arch of a tubular fuselage. Consequently, its peak height is nine feet, but it decreases to less than six feet at the sides.

Aircraft for Hardened Bases

Given that their costs will limit the number of large-aircraft shelters constructed, base hardening should be matched to the most capable aircraft available in terms of range/offload capabilities. In the Air Force's program-of-record fleet—what it has and intends to acquire—the most capable air refueling aircraft will be the KC-10 and the KC-46. Their higher offload capacities and greater speeds will allow these aircraft to refuel larger or more aircraft and penetrate deeper into contested airspaces that have a low to medium threat risk and still survive. In comparison to KC-46s, KC-10s would require marginally larger shelters.²⁴ Whether the operational return on investment of moving KC-10s forward would be worth their additional shelter costs is a matter for more detailed analysis than possible here.

Aircraft for Disaggregated Basing

All tanker aircraft types are suitable for disaggregated basing so long as bases are available and they have adequate runways and parking areas. Their ability to operate from shorter and softer airfields, combined with greater maneuverability on the ground and ability to taxi or be towed on unsurfaced areas, would give C-130s and A400s some flexibility and resiliency advantages over airliner-derived tanker designs, such as KC-10s and KC-46s. However, the advantage is likely to be marginal, particularly in the gorilla ring where enemy capabilities to detect, target, and strike air refueling assets will be at their peaks. Those capabilities and the near certainty that enemies will know which airfields were prepared to host fixed-base disaggregated operations will render air refueling aircraft, facilities, and personnel highly vulnerable to a wide range of attacks.

Aircraft for Agile Basing

Again, any of the three aircraft could participate in agile basing, but the ground maneuverability of the C-130J and A400M would offer significant advantages in resilience. Compared to airliner-derived designs, C-130Js and A400Ms will be able to utilize many more of the kinds of airfields typical of lesser-developed areas of the world (including austere landing zones) and to shift about those airfields more flexibly and with greater dispersal. The airfields clustered around the Bohol Sea in the southern Philippines offer an almost ideal environment for sea-based support of agile and disaggregated tanker basing (fig. 2). All of them are within support distance of a single ship maneuvering in the area, and all are near coastlines or harbors that would

allow refueling from tanker ships. While few of the available fields have runways adequate for fully loaded KC-46s, all of them could handle C-130Js and A400Ms.

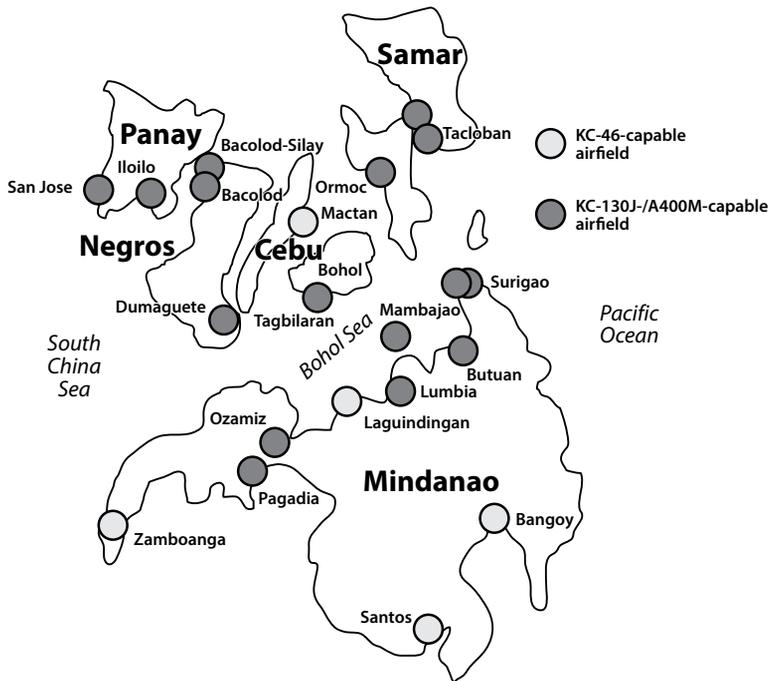


Figure 2. Airfields in the Bohol Sea area of the southern Philippines

Additionally, the ability of these military transport-derived tankers to taxi, be towed, and to park on unsurfaced areas will greatly increase the uncertainty of enemy forces attempting to target them. The paved parking spots at most of these airfields are located on single ramps capable of accommodating only a few aircraft. Aircraft constrained to use such parking areas would be vulnerable to destruction in mass by unitary and area weapons (fig. 3). The predictability of these parking areas also would allow enemy commanders to release weapons against them with a high probability of success, even when shooting “in the blind.” However, most of these airfields also have runway margins and other areas composed of various grades of laterite and are therefore usually able to sustain the movements of C-130Js and A400Ms. By dispersing dynamically among such off-concrete parking spots, disaggregated tanker units would deny enemy commanders any certainty of

hitting useful targets with weapons released on the basis of anything but real-time or near-real-time information.

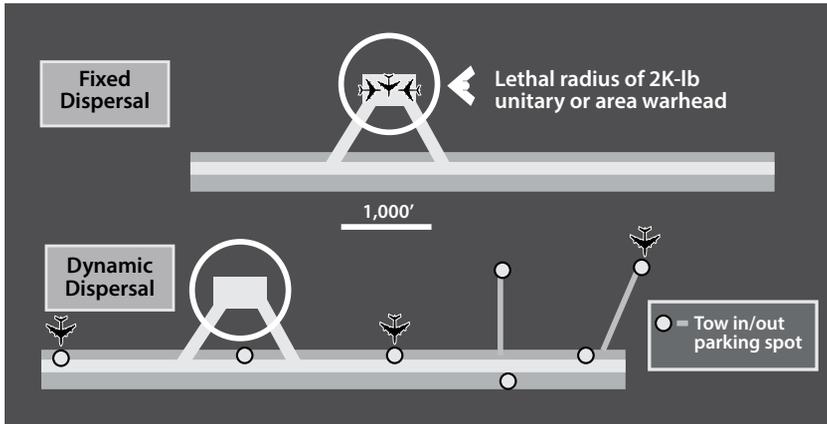


Figure 3. Fixed and dynamic dispersal vulnerabilities

It is important to understand that the A400M and KC-130J are not equivalent aircraft. While both aircraft can operate from the same airfields, the A400M offers substantial operational advantages over the smaller aircraft. The A400M's 420-knot cruise speed compares well to the 350-knot speed of the C-130J. Faster speed equates to refueling combat aircraft at higher altitudes and supporting them deeper into contested airspaces while retaining the ability to evade enemy interceptors. For example, an enemy fighter flying at 540 knots and trying to run down a fleeing A400M 100 miles away would require 49 minutes to close the gap but only 32 minutes to do the same thing with a KC-130J. Seventeen additional minutes is a long time for fighter pilots watching fuel gauges and for signs of enemy attacks on *them!* Also, the A400M's substantially larger range/offload capacity over the C-130J would either increase the fuel available from a given number of aircraft at an agile base or reduce the number of aircraft based forward to satisfy a given demand. The A400M's larger cargo "box" size and payload also enhances its utility as an organic mobility platform for disaggregated tanker units and as an augmentor of general airlift efforts at times of reduced demand for its refueling capabilities.

Recommendations

Drawing on unclassified data, this study sought to broaden discussion of whether an updated US strategy should emphasize hardened, disaggregated,

or agile concepts. It pursued that question by describing the worst-case antiaccess/area-denial threat environment US and allied tanker forces might face in the future. It then discussed the characteristics of each of the basing options in relation to that threat environment and closed with a consideration of which of the available aircraft types would be most compatible with each basing option.

The salient finding of the study is that the USAF should incorporate all three concepts into its air refueling program in a combination that optimizes overall fleet operational and life-cycle costs, resilience, and effectiveness. On a relatively limited scale and as elements of multilayered defense networks, hardened bases can offer an effective albeit very expensive means of protecting a small portion of the tanker fleet that absolutely must be based well forward. Simple disaggregation involving infrequent movements of supported units offers some opportunity to protect tanker forces. But the requirement to establish supply warehouses, access agreements, and the like would limit the protection offered by this concept to deployed forces unless they also accelerated their rate of movement. Fixed or semifixed disaggregation, therefore, would be best employed in the face of A2/AD capabilities degraded previously by friendly operations. Agile basing of disaggregated forces in the missile ring likely would offer the most generally resilient and cost-effective method of basing air refueling forces forward. Sea basing to support land-based aerial refuelers in insular or littoral areas also could maximize their basing agility and logistically supportable disaggregation. For air planners, the survivability of a supporting sea base in forward operations is a troubling question but one perhaps best answered in close discussion with the experts in the Navy and Marines. Finally, this study suggests that if the Air Force gets serious about agile basing, it needs to take a closer look at the advantages offered by the middle-option candidate aircraft—the A400M.

This study ends, therefore, by reaffirming that a mixed solution to the basing challenge likely will be the optimal one and by suggesting the obvious—that this issue is a realm of continued study. Most importantly, perhaps, the ongoing and generally classified discussion of large-aircraft basing options needs broadening to embrace a more energetic version of agile basing and to include and inform a broader gallery of analysts and interested parties. An intellectually open and informed look at sea basing in support of Air Force refueling and other operations deserves to be a part of this inquiry, as does the full range of aircraft options available. Without doubt, looking at these issues will obligate the Air Force to cross some interservice turf and expertise boundaries and, possibly, confront some politically well-entrenched manufacturer interests. If the Air Force intends to fight with its tankers forward,

these would be necessary next steps in developing the capabilities to do that in increasingly dangerous A2/AD environments.

Notes

1. The US Department of Defense generally defines *antiaccess* as “those actions and capabilities, usually long-range, designed to prevent an opposing force from entering an operational area” and *area denial* as “those actions and capabilities, usually of shorter range, designed not to keep an opposing force out, but to limit its freedom of action within the operational area.” See DOD, *Joint Operational Access Concept (JOAC)*, ver. 1.0, 17 January 2012, 6.

2. *Ibid.*, 19–20.

3. Ben Blanchard, “China’s President Xi Urges Greater Military Use of Space,” *Reuters*, 15 April 2014, <http://uk.reuters.com/article/2014/04/15/uk-china-defence-idUKBREA3E03G20140415>; and DOD, *Annual Report to Congress: Military and Security Developments Involving the People’s Republic of China 2014* (Washington, DC: DOD, 2014), 65.

4. Aircraft and missile force numbers from DOD, *Annual Report to Congress*, 2014, 7, 27, and throughout; Mark A. Stokes and Ian Easton, *Evolving Aerospace Trends in the Asia Pacific Region: Implications for Stability in the Taiwan Strait and Beyond* (Washington, DC: Project 49 Institute, 2014), 12-3; and Jonathan F. Solomon, “Defending the Fleet from China’s Anti-ship Ballistic Missiles: Naval Deceptions’ Roles in Sea-Based Missile Defense (master’s thesis, Georgetown University, 2011), 25.

5. “Missile Threat: DF-21/-21A/-21B/-21C/-21D (CSS-5),” George C. Marshall and Claremont Institutes, 14 November 2012, <http://missilethreat.com/missiles/df-21-21a-21b-21c-21d-css-5/>; and “Missile Threat: HN-1/-2/-3,” George C. Marshall and Claremont Institutes, 9 April 2013, <http://missilethreat.com/missiles/hn-1-2-3/?country=china#china>.

6. A useful chart can be found at “Mapping Migration,” *Economist*, 17 November 2011, <http://www.economist.com/blogs/dailychart/2011/11/diasporas>.

7. Roger Cliff et al., *Entering the Dragon’s Lair: Chinese Antiaccess Strategies and Their Implications for the United States* (Santa Monica, CA: RAND, 2007), 37–8 and 113–15.

8. For missile range specifications, see DOD, *Annual Report to Congress*, 2014, 85. Given the unavailability of definitive information on Chinese aircraft capabilities, this study presumes that their radii of action with strike-profile weapons loads will be roughly equivalent to those of late-model F-16s and F-18s, which fall between 350–450 nm.

9. John Stillion and David T. Orletsky, *Airbase Vulnerability to Conventional Cruise-Missile and Ballistic-Missile Attacks: Technology Scenarios and U.S. Air Force Responses* (Santa Monica, CA: RAND, 1999), 99; and Christopher J. Bowie, *The Anti-access Threat and Theater Air Bases* (Washington, DC: Center for Strategic and Budgetary Assessments, 2002), 58–65, for examples of this widely held position.

10. Cliff et al., *Entering the Dragon’s Lair*, 99.

11. DOD, *Annual Report to Congress*, 2014, 32.

12. For insights into China’s uncertain and contradictory approach to modernized command and control, see Zhao Shengnan, “New Joint Command System ‘On Way,’” *China Daily*, 3 January 2014, http://usa.chinadaily.com.cn/china/2014-01/03/content_17212780.htm; and for the military’s quick rebuttal, see Bai Tiantian and Liu Yang, “No Joint Command: MOD,” 6 January 2014, *Global Times*, <http://www.globaltimes.cn/content/835937.shtml>. For analysis of the situation, see James Mulvenon, “Rearranging the Deck Chairs on the *Liaoning*? The PLA Once

Again Considers Reorganization,” *China Leadership Monitor*, 14 March 2014, <http://www.hoover.org/publications/china-leadership-monitor>.

13. Carlo Kopp, “Hardening RAAF Air Base Infrastructure,” *Air Power Australia*, 5 February 2008, 20.

14. This figure probably is on the low side of actual costs. Given the unavailability of direct data, it is an extrapolation of available costing data for standard hangars and smaller hardened shelters. It also reflects the very useful engineering and costing data on a notional large aircraft hangar provided by Thomas Watts, presently the general manager of Spantech Pty Ltd, Australia. Criticisms by individuals ready to release better data would be welcome.

15. DOD, *Joint Operational Access Concept*, 20.

16. *Ibid.*, 37.

17. Bruce Felknor, “Top Secret Project Ivory Soap—Aircraft Repair Ships,” *American Merchant Marine at War*, accessed 24 February 2014, <http://www.usmm.org/felknorivory.html>.

18. David Kummer, “Aviation Logistics Support: The T-AVB’s Role in Aviation Logistics Planning,” *Marine Corps Gazette*, September 2012, 52–53.

19. “Logistical Impact of Seabasing,” Second Line of Defense, accessed 20 July 2014, <http://www.sldinfo.com/the-logistical-impact-of-seabasing/>; and Bradley Weisz, “The Bold Alligator 2012 Approach,” Vimeo, video, 04:54, accessed 21 July 2014, <http://vimeo.com/35058483>. Colonel Weisz, deputy commander of Expeditionary Strike Group Two, was discussing exercise Bold Alligator 2012, an experiment in supporting multiple ship-based aviation units from a single T-AVB. General information on T-AVB employment from John Reardon, US Maritime Administration, Division of Sealift Operations and Emergency Response, datasheet provided to author, 25 May 2014.

20. Capt Charles Walker, USN, retired, telephone interview by the author, 27 March 2014; and Timothy R. Neuman, telephone interview by the author, 4 March 2014. Captain Walker commanded the *Tallahatchie County* in 1968–69. See also *Tallahatchie County* veterans website, accessed 20 June 2014, <http://www.usstallahatchiecounty.com>.

21. The cruise speed of the UH-60 helicopter is about 150 knots and its operational radius about 300 nm. Given the operating and maintenance characteristics of helicopters, however, the practical radius of routine support likely will be shorter.

22. Current expeditionary fuel systems include the Air Force’s system of Fuels Operational Readiness Capabilities Equipment (FORCE) and the Marine Corps’ AABFS and TAFDS. The Marine Corps systems are particularly relevant to maritime environments since they can be set up, connected to offshore tanker ships, and put into initial operations in just a few hours.

23. See Marine Corps Systems Command (MCSC), “Tactical Airfield Fuel Dispensing System (TAFDS),” TM 12359A-OD, data sheet, accessed 5 August 2014, <http://www.marcorsyscom.marines.mil/Portals/105/pdmeps/docs/FUEL/B0675.pdf>; MCSC, “Amphibious Assault Fuel System (AAFS),” TM 12359A-OD, accessed 5 August 2014, <http://www.marcorsyscom.marines.mil/Portals/105/pdmeps/docs/FUEL/B0685.pdf>; and Lance Cpl Keenan Zelazoski, “Fueling Fighting from Ship to Shore: Bulk Fuel Co. Demonstrates Capabilities of Amphibious Assault Fuel System,” 1st Marine Logistics Group, 15 April 2014, <http://www.1stmlg.marines.mil/News/1stMLGNews/tabid/17231/Article/545107/fueling-fight-from-ship-to-shore-bulk-fuel-co-demonstrates-capabilities-of-amph.aspx>.

24. The KC-10 is 181 ft. long, with a wingspan of 165 ft. and a height of 58 ft. while the dimensions of the KC-46 are 165 ft., 157 ft., and 52 ft., respectively.

Abbreviations

AABFS	amphibious assault bulk fuel system
A2/AD	antiaccess/area denial
DOD	Department of Defense
ISR	information, surveillance, and reconnaissance
MRBM	medium-range ballistic missile
nm	nautical mile
SOF	special operations forces
SRBM	short-range ballistic missile
TAFDS	tactical airfield fuel dispensing system



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