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CHINA'S "ANTIACCESS" BALLISTIC MISSILES AND U.S. ACTIVE DEFENSE

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Relations between Taiwan and China have improved recently. At the same time, U.S.-Japanese relations have worsened, partly as the result of disagreements over Futenma Marine Air Station on Okinawa. As a result, the prospects of fighting between the United States and China over Taiwan and of U.S. reliance on Okinawa bases to supplement carrier airpower in the course of such a fight appear far-fetched, disastrous for the states concerned.

Of course, military professionals and the defense analytic community need to think through unlikely and unwelcome scenarios.[1] To that end, various analysts have contributed to a lively discussion of Chinese "antiaccess" systems designed to keep the United States at bay in the event of conflict.[2] These systems include C4ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance) assets like over-the-horizon (OTH) radar and increasing numbers of satellites, a more modern air force, more submarines with better weapons, and both cruise and ballistic missiles to hold at risk our ships at sea and our air bases ashore.[3] This article examines ballistic missile threats to carriers and air bases and the adequacy of U.S. active defenses.

China seeks the capacity to find U.S. aircraft carriers roughly a thousand miles from the mainland and to attack them with homing ASBMs (antiship ballistic missiles).[4] China must overcome serious technological challenges to field the systems needed to do these things. The United States faces the prospect that

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China might overcome these challenges, perhaps as soon as five years from now. To attack fixed targets like American air bases in Japan, China has already developed a family of road-mobile, solid-fuel, short-range ballistic missiles.[5] One of these missiles, the CSS-6, has the range to attack Kadena Air Base on Okinawa, a U.S. Air Force facility that is in many ways the best air base ashore for U.S. operations against China.[6]

The current U.S. response to these developments relies heavily on active defense —that is, deployment of antiballistic missiles (ABMs). To defend ships at sea, the United States is investing in Aegis/Standard Missile ABMs, and to defend air bases ashore, in Patriot PAC-3 ABMs. The Navy originally developed Aegis ballistic-missile defense (BMD) to protect assets ashore, such as seaports of debarkation. Given China's ASBM efforts, however, many officers see the counterASBM mission as an important role for Aegis BMD. Indeed, the commander of the U.S. Pacific Fleet, Admiral Patrick Walsh, recently characterized missile defense as "essential to our ability to operate freely."[7]

MY ARGUMENT IN A NUTSHELL

The U.S. ABM investments just described deserve critical scrutiny: asymmetries in the competition of Chinese ballistic missiles versus U.S. antiballistic missiles make it unlikely that active defense alone will succeed. To see why, we need to review China's ASBM system threat to ships at sea and China's short-range ballistic missile (SRBM) threat to U.S. air bases.

Active Defense against the ASBM System. What is the asymmetry in the ASBM versus ABM competition? On one hand, China can easily determine how many ABMs the United States is building and compute the limited number that each ABM-configured Aegis ship will likely have aboard. Should it succeed in developing ASBMs that work and systems that can detect, locate, and track U.S. aircraft carriers, China can overcome active defenses by launching more ASBMs than the United States can possibly intercept.[8] It can do so with relative ease even if Aegis/ABM systems have high single-shot kill probabilities, because Beijing's entire ASBM inventory is available.

The United States, on the other hand, can devote only a subset of its ABMs to protecting carriers from the ASBM threat. Even if the Navy makes heroic efforts to increase the fraction that is forward deployed in the western Pacific, China will retain its "home field" numeric advantage. The United States cannot "buy its way out" of this problem by acquiring larger numbers of Standard Missile 3s (SM-3s). First, China can add additional ASBMs to its inventories at substantially lower costs than those the United States would incur by adding offsetting numbers of ABMs.[9] Second, if China proves able to meet the difficult technical obstacles required to mount ASBM attacks, it should be readily able to surmount the easier technical challenges involved in fielding dirt cheap decoys that can lead astray already-scarce ABMs.

Suppose that Chinese C4ISR is able to detect, locate, and identify carriers within ASBM range and a Chinese salvo proves able to overwhelm Aegis BMD defenses. Does it follow that the penetrating ASBMs will succeed in hitting U.S. carriers? Not necessarily. Much depends on the area of uncertainty (AOU) that China faces, given its C4ISR capabilities, and on the "seeker footprint" of the guidance radars on each ASBM warhead reentry vehicle. If the AOU is large and seeker footprints are small relative to that AOU, China's inventory may be too small to fire the number of ASBMs needed to get a hit. For this reason, the Navy needs to do all that it cost-effectively can to increase the size of the AOU and thereby force China to commit large numbers of ASBMs to cover it.

Active Defense of Air Bases against Ballistic Missiles. Depending on how a Taiwan contingency unfolds, U.S. land-based aircraft might perform important roles. However, their potential contribution diminishes the farther those bases are from the Taiwan Strait. If available for use, Kadena Air Base on Okinawa would easily prove the most valuable.

China has 350 to 400 CSS-6 ballistic missiles capable of reaching Kadena. A fraction of those missiles might put it out of action, in either of two ways: they might deliver unitary warheads that crater runways, or they might deliver cluster munitions that destroy unsheltered aircraft on the ground. This prospect is especially worrisome for "big wing" aircraft like AWACS (the Airborne Warning and Control System), tankers, and the P-3 Orion maritime patrol aircraft, since they are too large to place in shelters.[10] China's best choice would appear to be a combination attack—cratered runways to fix aircraft in place for destruction by follow-on cluster munitions.

The U.S. Army has based a Patriot battalion armed with the PAC-3 ABMs at Kadena. Whether the PAC-3 can prevent Chinese missiles from putting Kadena out of action depends on factors impossible to predict with certainty. These factors include China's decision at the time about what fraction of its missile inventory to devote to Kadena attacks and also U.S. choices about what fraction of the global PAC-3 inventory to send to Kadena. That said, China enjoys, again, a "home field" advantage in that its entire CSS-6 inventory is available, whereas the United States needs PAC-3s in distant theaters, like the Persian Gulf.[11]

What's Next? I provide below the evidence behind each of the assertions in the argument just summarized. First, I focus on the ASBM problem. I recap the hurdles—mainly technical but also organizational—that China would have to overcome to field an ASBM system. Next, I review Department of Defense

(DoD) projections of Chinese ASBM and American antiballistic-missile inventories. I discuss what ASBM-versus-ABM exchanges might look like, given those inventories.

Next, I discuss the CSS-6 threat to Kadena.[12] Given the potential contributions of land-based aircraft, I compare Kadena to other western Pacific U.S. air bases. I discuss the numbers of CSS-6s needed to put Kadena out of action and compare CSS-6 inventories to those of PAC-3 ABMs.

Against this background, I discuss U.S. choices. I argue against planning to "thin the (ASBM) herd" by attacks on Chinese soil. Instead, I argue that the United States should devote more effort to developing and rigorously testing passive defenses and to fielding those that look likely to perform well in defeating China's ASBM system and its ballistic missiles that threaten air bases ashore. If passive defense of ships or land bases appears inadequate to offset the limitations of active defense despite such efforts, I argue, the United States should consider a wider range of alternatives to defend its interests in the western Pacific.

BALLISTIC MISSILES VS. AIRCRAFT CARRIERS: CHINA'S ASBM PROGRAM AND U.S. ACTIVE DEFENSE

China has to overcome a series of tough technical challenges to enable ASBM strikes on carriers at sea. Recent analyses have outlined these challenges in detail.[13]

The first tasks for an ASBM system are to detect a carrier, identify it, and locate it with enough precision to launch missiles. In principle, China might perform these tasks from such platforms as fishing boats or merchant ships, submarines, surface ships, or manned and unmanned maritime reconnaissance aircraft. China might also rely on its developing OTH radar. However, though some combination of these systems might work in the future, few observers judge them adequate today. (Of course, one or more of these systems might suffice even now. For example, a carrier might pass close to a Chinese submarine, as USS *Kitty Hawk* did in October 2006.)

Analysts Eric Hagt and Matthew Durnin have reviewed the potential contribution of various kinds of satellites and identified strengths and limitations of each. They say that satellite-borne ELINT (electronic intelligence) and SIGINT (signals intelligence) systems could provide "long-distance early warning."[14] However, their apparently exhaustive list makes no mention of ELINT satellites. I conclude that China now has few such satellites, if any. As long as that is true, China will be able perform ELINT/SIGINT missions for only part of each day (a large number would be required to keep potential carrier operating areas under continuous surveillance). That limitation matters because the United States can tell when SIGINT satellites come within range of carriers. During those periods, the United States can use emission control (EMCON) to defeat SIGINT.[15] The shorter those periods, the better for the United States, because EMCON can sharply reduce a carrier's operational effectiveness.

Of course, China needs other capabilities to enable its satellite constellation to provide targeting-quality data to ASBM launchers. Hagt and Durnin observe that "China . . . lacks C4ISR infrastructure—such as information processing, bandwidth capacity, and network support—needed for wide-area surveillance."[16] In addition, they note "organizational and bureaucratic barriers impeding the ability of disparate space assets to perform highly time-sensitive missions," such as precise location of a moving carrier far at sea.[17] Similarly, Thomas Ehrhard and Robert Work state that "even when PRC [People's Republic of China] engineers fit all of the technical pieces together, it will take even more time for the PLAN, PLANAF, and PLAAF [respectively, the People's Liberation Army Navy, Naval Air Force, and Air Force] to develop the tactics, techniques, and procedures necessary to convert their disparate systems and combat methods into a truly effective joint operational network."[18]

Despite these obstacles, Hagt and Durnin apparently regard a space-based system as China's best hope for detecting, locating, and tracking carriers in the foreseeable future. Indeed, they assert that if everything goes as well for China as they think possible to imagine, "a system competent to provide near-real-time regional coverage could be five years away."[19]

A second set of technological challenges confronts China even if it can get targeting-quality data to the mobile transporter-erector launchers (TELs) of its ASBM and launch weapons promptly. Those challenges involve building an ASBM whose reentry vehicle (RV) seeker can identify and track the carrier and guide the RV to hit it. For example, "reentry into the atmosphere . . . would produce a plasma shield, making homing by radar and infrared difficult."[20] Other technical obstacles include development of "materials needed to protect sophisticated guidance systems during reentry; the ability to function in an environment of higher speed and more severe temperature dynamics than in earlier applications; and the ability to distinguish a target at unusual angles of attack at the distances required for reentry."[21]

How Many Missiles?

Chinese analysts identify a third major set of technological hurdles—those involved in penetrating U.S. active defenses.[22] Those analysts are unduly pessimistic concerning this problem. To see why, we need to consider the numbers in each side's inventories.

How Many ASBMs Will China Field? China's ASBM will use the DF-21D airframe, which will enter production this year.[23] Over the past four years China has produced DF-21s of earlier models at the rate of nine to fifteen per year.[24] In light of increased funding for SM-3s that DoD announced earlier this year, it is plausible that China will produce DF-21Ds at the higher of these rates. If so, and if it earmarks ten DF-21Ds for testing, China will have eighty ASBMs by the end of 2015.[25]

How Many ABMs Will the United States Have? The Navy has configured eighteen Aegis ships (fifteen *Arleigh Burke*–class destroyers and three *Ticonderoga*-class cruisers) for anti–ballistic missile missions worldwide and will add six more.[26] It will equip such ships with two ABM models of its Standard Missile: the SM-2 Block IV and the SM-3.[27] The SM-3 is designed to intercept ballistic missiles beyond the atmosphere. The SM-2 Block IV is an interim missile, based on the SM-2 airframe, originally intended for "air-breathing" targets. It will intercept reentry vehicles in their terminal phase.

The Navy had forty SM-2 Block IVs at the end of 2008.[28] It originally announced an inventory target of a hundred of these missiles. More recently, senior officials have mentioned targets of seventy or eighty missiles.[29] The Navy had thirty-eight SM-3s at the end of 2008. As a result of an ABM-investment increase announced by Secretary of Defense Robert Gates in April 2009, the Navy intends to have an inventory of 220 SM-3s by the end of 2015.[30]

How Many ABMs Will Be Available to Counter the ASBM Threat? The Navy faces demands for ballistic-missile defense in several places. The Congressional Budget Office estimates that the Navy will need seventy-two SM-3s to defend Europe against Iranian missiles.[31] U.S. Central Command has said that it needs Aegis BMD capability to defend friends in the Middle East. Given North Korea's ballistic-missile program and hostile rhetoric, the Navy will likely need to devote some Aegis BMD capability to countering that threat. Since Iran and North Korea field relatively unsophisticated ballistic missiles, let us assume that the Navy decides to devote its SM-2 Block IV missiles to these missions; further, to establish a bounding case favorable to active defense against ASBMs, let us assume that the Navy allocates none of the inherently scarce SM-3s to Middle East or UNorth Korea missions. (Japan's posture makes it especially plausible that the United States would earmark only SM-2 Block IV ABMs against North Korea —Japan has acquired Aegis/BMD ships and plans to buy SM-3 Block II missiles.)

Given the demands just described, what allocation of Aegis BMD ships appears plausible? The Congressional Budget Office assumes that DoD would need nine ships, including three deployed forward, for the defense of Europe against Iran.[32] For purposes of this analysis, I assume the Navy would need to maintain at least one Aegis BMD ship forward deployed in or near the Persian Gulf for Middle Eastern defense and at least three additional Aegis BMD ships to support this rotation (i.e., to keep one ship on station continuously). Similarly, I assume one Aegis BMD ship forward deployed in the Sea of Japan, but (owing to relative proximity to U.S. ports) only two additional ships to support the rotation.

Table 1 summarizes the 2015 regional allocation of Aegis ships and ABMs, given the assumptions just described. It shows that the Navy would devote thirteen Aegis BMD ships to countering Iran and three to North Korea. This would leave eight for a Chinese contingency. Similarly, the Navy would devote seventy-two SM-3s to European defense and all seventy or eighty SMK-2 Block IVs to the Middle East or North Korea roles. Of the 220 SM-3s produced by 2015, therefore, the Navy could earmark 148 for China. If the Navy allocated those missiles to six of the eight China-rotation ships, each would have twenty-four or twenty-five aboard. (Of course, the total number available for China contingencies might be lower if larger numbers were devoted to the counter-Iran European-defense mission.)

What Might ASBM-vs.-ABM Exchanges Look Like?

To answer this question, we need to consider the targeting problem that each side faces and to make explicit some simplifying assumptions. First, I assume that the U.S. Navy would enjoy perfect warning and perfect positioning. In other words, I assume that Aegis ships would know of ASBM launches virtually instantaneously and that they would then direct radar energy exactly where it should be directed. In possible future combat, of course, they might not enjoy these advantages.

TABLE 1
ASSUMED 2015 ALLOCATION OF ABMs AND AEGIS BMD SHIPS

Combatant Command	Threat	ABMs		Aegis BMD Ships	
		SM-3	SM-2 Block IV	Total Number in Rotation	Subset Deployed Forward
EUCOM	Iran	72	0	9	3
CENTCOM	Iran	0	70–80	4	1
PACOM	DPRK	0		3	1
PACOM	PRC	148	0	8	2–3
Inventory Totals		220	70–80	24	7–8

Note: EUCOM = U.S. European Command; CENTCOM = U.S. Central Command; PACOM = U.S. Pacific Command; DPRK = North Korea.

Second, I assume that absent enemy countermeasures, each side's missiles would perform well. I assume that the ASBM would have a high probability of hit against a correctly identified and located carrier and that in turn the SM-3 would have a high probability of hit against a correctly identified and located ASBM reentry vehicle. Compared to actual historical experience involving large numbers of guided missiles, these estimates appear optimistic.[33]

The U.S. Navy's Targeting Problem. The Navy would almost certainly fire two ABMs against each of the incoming ASBMs.[34] Doing so would of course increase the probability of a successful intercept. However, with only twenty-four or twenty-five ABMs aboard, each Aegis ship escorting a carrier would at that rate be able to engage at most thirteen ASBMs. Even if each ABM individually performed as well as the Navy could reasonably expect, the fourteenth would get past active defenses.

So what should we expect if an ASBM-vs.-ABM clash were to occur in 2015, which some judge the earliest that Chinese satellites would provide data sufficient for an attack?[35] As noted earlier, China might plausibly have eighty ASBMs available by that time. If so, the United States would have to have 160 ABMs on hand—more than the 148 ABMs in its entire "China inventory"—to fire two against each incoming antiship missile.

Suppose that China produced fewer than ninety DF-21Ds by 2015 or used so many in testing that it had too few to overwhelm U.S. defenses as just described. In that case, it could seek to increase the odds in its favor in other ways. First, it might fire earlier-model DF-21 missiles alongside its DF-21D ASBMs. (It could have almost thirty such earlier-model missiles available for use in this way.)[36] Second, China might deploy other kinds of decoys. For example, Chinese engineers could design ASBMs to deploy aluminum-coated Mylar balloons during the exo-atmospheric phase. The actual warhead would be inside one of the balloons; the other balloons would have lithium batteries to simulate the heat escaping from the balloon with the warhead, making it virtually impossible to distinguish the warhead from the decoys.[37] Third, it might develop penetration aids aside from decoys. For example, Chinese engineers could defeat a hit-to-kill intercept by enclosing the ASBM warhead in a cooled shroud, making it difficult for the infrared sensors of the ABM "kill vehicle" to detect. Finally, it might choose some combination of the above approaches or adopt them all. Again: the fact that many kinds of penetration aids are quite cheap relative to ABMs is one reason why the United States cannot "buy its way out" of this problem.

Unfortunately, the public record provides little reason to be confident that the SM-3s now being produced can defeat the kinds of countermeasures just described. Indeed, that record strongly suggests that tests of Aegis/SM-3's ability to distinguish decoys and defeat other countermeasures have not yet been conducted. (Two pieces of evidence deserve note. First, of over sixteen tests and nineteen cumulative SM-3 firings, the Missile Defense Agency [MDA] or the Navy publicized every test's objectives save one. Tests against decoys or countermeasures were never mentioned. Second, BMD critics frequently cite countermeasures and decoys in explaining their skepticism. This means SM-3 developers have strong incentives to announce such tests. That they have not strongly suggests that the United States has not yet conducted any, let alone tested SM-3s with the frequency needed to build confidence, given the variety of possible countermeasures.)

China's Targeting Problem. Imagine that China overcomes each of the technological and organizational hurdles identified earlier and that its ASBM system passes a series of tough operational tests. Next, assume that China's sensors detect, identify, and locate a carrier and that it decides to shoot. In such a situation, China would need to consider two aspects of system performance in deciding how many ASBMs to launch. Since the carrier will have moved by the time ASBMs are fired, China would have to estimate the size of the area of uncertainty it faces. Next, China would have to decide how many midcourse seekers would be needed at least to cover that AOU. Finally, China would need to estimate the probability that those seekers would correctly identify the carrier despite the possible presence of other high-radar-cross-section ships.

The first sidebar's analysis implies that China's AOU would be a circle with a radius of at least thirty-one kilometers. The second sidebar shows that much depends on the RV seeker's "footprint"—the area on the surface that the seeker can search to find its target. If China were in fact able to field a seeker with a one-hundred-kilometer-radius footprint, only one RV penetrating U.S. active defenses would be adequate to cover the entire AOU. On the other hand, a twenty-kilometer-radius footprint would mean that China would need at least six penetrating RVs to do so. If the AOU proved substantially larger, which might happen if Chinese leaders deliberated at length before deciding to shoot, far more RVs (and accordingly ASBMs) would be needed.

An Assessment

The facts reported above suggest that the United States cannot counter the ASBM threat by buying more SM-3s. Were it to try to do so, China could offset these efforts by investing in decoys and other countermeasures; it might even be able to increase ASBM production. However, the United States might counter the ASBM threat by developing hardware and operational concepts that increase

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ESTIMATING THE AREA OF UNCERTAINTY

As noted earlier, Hagt and Durnin say that China's satellite systems might be able to collect data sufficient to detect, locate, and identify an aircraft carrier (CV) within ASBM range by 2015. (They note, however, China will have too few satellites to track the CV continuously.) They point out that data from reporting satellites would have to be transmitted to a ground station for processing. They note that the U.S. data link system has greater bandwidth than China's; even so, they say, it would take the United States five minutes to transmit such data. Given these observations, I assume this transmission would take more than five minutes but use that figure as a lower bound. Once transmission was complete, the ground station would need time to process the data and estimate the CV's location. In addition, ASBM-carrying TELs would need ten to fifteen minutes to prepare to fire. If we assume that those TELs would be told to begin those preparations soon after the ground station received needed data, we might conclude (optimistically for China) that fifteen minutes would be sufficient for both ground-station data analysis/sensor fusion and TEL launch preparation. If the TEL fired on completing those steps, the ASBM would require another twelve to fifteen minutes to fly to the target. At a minimum, therefore, from thirty-two to thirty-five minutes would elapse between the time that satellites gathered necessary data and when the ASBM hit. At thirty-five knots, the carrier could travel roughly thirty-one kilometers in that time.

Note that the timeline just computed implicitly assumes that China's political leaders have given orders to its military to fire as soon as it has precise carrier-location data. This assumption may well prove wrong if the United States and China were not yet shooting at each other. In that case, China's political leaders might want to be notified when a CV was identified and located within range, so that they could decide whether to attack, on the basis of their up-to-the-minute assessment of the political situation. If so, a delay while the politicians decide what to do is quite likely. The longer that delay, the greater the chances that the AOU would grow so large that Chinese satellites would have to locate the CV again.

HOW MANY ASBMS ARE NEEDED TO COVER THE AOU?

The Office of Naval Intelligence (ONI) expects China's ASBM's warhead reentry vehicle to use an on-board high-altitude radar seeker to look for the carrier and to correct its trajectory accordingly. As the RV gets closer to earth, ONI apparently expects, active radar would take a "second look" and guide the ASBM's RV until it can rely on a "passive" seeker to guide it the rest of the way to the target.*

Given the process just described, Chinese weaponeers need to know the ASBM RV radar seeker's "footprint"—the size of the area on the earth's surface that it can search. Even if the United States had no active defenses, China would need to plan to shoot enough ASBMs so that, taken together, their seeker footprints would cover the AOU.

Hagt and Durnin report that Chinese analysts have referred to a "'kill radius' (the distance the target could deviate from initial position and still be struck)" for a carrier targeted by an incoming ASBM. They cite three different Chinese kill-radius estimates: twenty, forty, and a hundred kilometers. It is unclear whether the Chinese analysts who made the twenty- and forty-kilometer estimates did so based on seeker capabilities or arrived at these figures some other way. Of course, "kill radius" as just defined only applies if the ASBM's seeker can cover the entire circle. Therefore, table 2 uses these figures as the radii of "seeker footprints," to illustrate the minimum number of RVs required to cover the first sidebar's thirty-one-kilometer minimum-radius AOU and, for comparison, a sixty-kilometer AOU. (I used hexagonal approximations to make these estimates and rounded upward.)

* This description is based on the ONI illustration in Stokes, *China's Evolving Conventional Strategic Strike Capability,* p. 21.

TABLE 2
NUMBER OF RVS REQUIRED GIVEN AOUS OF VARIOUS SIZES

AOU Radius (km)	RV Seeker "Footprint" Radius Estimates		
	20 km	40 km	100 km
31	6	1	1
60	13	6	1

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the size of the AOUs that China sees and that drive up the chances that Chinese seekers will direct RVs to the wrong targets or fail in other ways.

CHINESE BALLISTIC MISSILES VS. U.S. AIR BASES ASHORE: CSS-6 VS. KADENA

Land-based aircraft could make important contributions in the event of conflict over Taiwan. Big-wing planes like tankers and AWACS would act as "force multipliers" for fighter/attack aircraft operating from both land bases and carriers.

Why Focus on Kadena? A recent RAND analysis asserted that the U.S. Air Force can conduct air operations most efficiently from bases no more than five hundred miles away from the target.[38] Kadena, at 460 miles, is the only U.S. air base within five hundred miles of the Taiwan Strait. Table 3 provides relevant data concerning the next-closest U.S. bases.

The "distance to the strait" column understates Kadena's advantage compared to Osan and Kunsan. Both Korean bases are more vulnerable to Chinese attack, since they are roughly four hundred kilometers from the closest Chinese territory; Kadena is more than six hundred kilometers distant. In addition, if big-wing aircraft were to operate from Korean bases, they would likely not fly directly to operating areas east of Taiwan. Such a flight path would place these planes dangerously close to China and make them vulnerable to attack by Chinese fighters. Of course, a more circuitous route would reduce the time they could spend on station in support of carrier- or land-based fighter/attack aircraft. In addition, such a route would reduce even further the amount of fuel that tankers could deliver.

How Many CSS-6s Would Put Kadena Out of Action? Suppose that China sought to crater Kadena's runways. Given highly accurate missiles, it might do so with as few as twelve unitary warheads.[39] Six warheads could divide each 3,700-meter runway into three segments, none of which would be long enough to permit fighters—to say nothing of AWACS or tanker aircraft—to land.

TABLE 3
U.S. AIR BASES ASHORE CLOSEST TO TAIWAN

Air Base	Number of Runways	Runway Length(s)	Fixed-Wing Aircraft	Distance to Taiwan Strait (km/mi)
Kadena	2	3,700 m	F-15, E-3 AWACS, P-3, RC-135V/W Rivet Joint, RC-135U Combat Sent and WC-135 Constant Phoenix, F-22*	740/460
Osan	1	2,743 m	F-16, OA-10	1,360/845
Kunsan	1	2,743 m	F-16	1,263/785
Iwakuni	1	2,440 m	F/A-18, F-35†	1,424/885

Notes:
* F-22s from Elmendorf Air Force Base, Alaska, routinely deploy as units to Kadena.
† The Marines reportedly plan to operate F-35s from Iwakuni.

Calculations based on RAND Corporation analyses show that forty CSS-6 warheads configured as cluster munitions could completely cover all the areas where big-wing aircraft would stand between landing and takeoff.[40] (Some fighter-sized aircraft could survive such an attack, because Kadena has fifteen hardened shelters.) Of course, the effectiveness of a cluster-munition attack depends on how many large aircraft are on the ground at the time. Satellites could presumably report when many are present, and China could launch CSS-6s soon after.

China's best approach would appear to be a combination attack. First, it could fire missiles to crater runways and prevent aircraft from taking off. Next, it could fire missiles with cluster munitions to destroy unsheltered aircraft. (Of course, China would do well to develop and employ still other weapons to help its ballistic-missile attack succeed. For example, it might employ antiradiation missiles [ARMs] to attack Patriot radars.)

If the United States were willing to bear the costs associated with preparing for a war that most observers judge unlikely, it could make preparations that would reduce Kadena's vulnerability to attacks like those just described. Rapid-repair kits might enable ground personnel to restore runways to operable condition. Additional shelters would permit F-15s and F-22s to ride out attacks. Whether the U.S. Air Force would be willing to budget for such passive defenses is an entirely separate question, of course. (Fliers prefer buying airplanes to buying concrete. They sometimes act like they need to buy planes just in case but will somehow know to buy concrete just in time.)[41] In any case, shelters for big-wing aircraft seem prohibitively costly.

What Is the ABM-vs.-CSS-6 Balance at Kadena? Kadena's Patriot battalion reportedly has four missile batteries armed with the PAC-3 ABM. Patriot batteries nominally have eight launchers apiece; each PAC-3 launcher has sixteen missiles. Even if the Kadena PAC-3 battalion has no reloads for its launchers, these figures imply an inventory of 512 (i.e., $4 \times 8 \times 16$) missiles. DoD reports that it will have bought 791 PAC-3 missiles by the end of fiscal 2010;[42] accordingly, a Kadena inventory of 512 missiles would constitute roughly two-thirds of all U.S. PAC-3 missiles worldwide.

The Army has fourteen Patriot battalions. Not all are armed with the PAC-3 missile. Even so, it does not seem plausible, especially in light of the Iranian missile threat, that a single battalion on Okinawa would have two-thirds of all PAC-3 missiles. So let us assume that only 264 PAC-3s (roughly a third of the total) are based there.

Suppose we also assume that Kadena's Patriots enjoy perfect warning and engage incoming Chinese CSS-6s with two PAC-3s apiece. If so, these ABMs could engage 132 Chinese missiles. If each PAC-3 enjoyed a 0.7 probability of kill (P_k), Kadena's ABMs would destroy all but twelve of these 132 incoming missiles. The 133rd missile and all that followed would be unopposed.

Given these assumptions, China could crater Kadena's runways and destroy all unsheltered aircraft by firing 172 CSS-6s. DoD reports that China has 350 to 400 CSS-6 missiles and is building from twenty to forty more each year.[43] Thus, inventory numbers alone suggest that China has a "home game" advantage in the competition of CSS-6 vs. PAC-3 analogous to the advantage it enjoys in the contest of ASBM vs. SM-3. (Of course, China would need far fewer CSS-6s if it destroyed Patriot radars with ARMs.)[44]

Of course, much depends on circumstances impossible to predict. If a Taiwan crisis were to arise after missile attacks on friends of the United States in the Middle East, for example, Kadena might have fewer PAC-3s than assumed above.

What Role Might THAAD and MEADS Play in Defense of Air Bases Ashore? Terminal High Altitude Area Defense (THAAD) is a hit-to-kill Army missile system designed to shoot down short-, medium-, and intermediate-range ballistic missiles in their terminal phases. THAAD has been in development since 1992 but only recently entered production. According to the Missile Defense Agency, "The THAAD missile is uniquely designed to intercept targets both inside and outside the Earth's atmosphere, making the use of countermeasures in their terminal phase difficult against THAAD."[45] If that prediction proves accurate, each THAAD missile deployed to protect Kadena will enhance active defense effectiveness there.

The MDA will deliver twenty-five THAAD missiles to operational units in fiscal year (FY) 2010. In the near future, MDA expects production of forty-eight THAAD missiles per year.[46] If most or all were devoted to defending Kadena, they would make active defenses more effective than otherwise. However, since THAAD will be available in relatively small numbers for several more years, these missiles might better be devoted to the defense of Andersen Air Force Base, on Guam.[47]

The Medium Extended Air Defense System (MEADS) is a joint U.S., German, and Italian project originally intended to replace the Patriot air-defense system. It was to "provide a robust, 360-degree defense against the full spectrum of ballistic missiles, anti-radiation missiles, cruise missiles, unmanned aerial vehicles, tactical air to surface missiles, as well as rotary and fixed wing threats."[48] If such a system were to be developed successfully and were then deployed in sizable numbers, it too might contribute to Kadena's defense. However, the Army has reportedly concluded that MEADS is too costly and unlikely to perform as needed.[49]

IMPLICATIONS FOR U.S. CHOICES

The "battle of the inventories" argument just made rests on DoD reports of Chinese missile production to date and projections about future ABM production, on competing demands for ABMs, on RAND analyses of Kadena vulnerability, and on the judgment of many analysts that China will prove able to field an effective ASBM system. The upshot is that active defenses likely cannot adequately counter the threat posed by China's "antiaccess" ballistic missiles.

If U.S. ABMs cannot defeat enemy countermeasures, of course, active defenses will prove even more inadequate. The variety of countermeasures China might field and the apparent failure to test ABMs rigorously against them makes the case for "business as usual" ABM acquisition even weaker. Given the limits of active defense, the United States needs to assess other ways of protecting carriers and air bases ashore. It must make such an assessment in light of the large costs and (as we have seen) limited benefits of buying all the ABMs called for in current plans. Indeed, the United States should decide which other initiatives for carrier and air-base defense deserve increased funding and effort, even at the cost of decreased funding and effort for active defense.

Such initiatives fall into two broad categories. On one hand are measures such as attacks on Chinese missile launchers. On the other hand are passive defense measures. Detailed discussion of these options is beyond the scope of this article. Instead, I provide examples of possible approaches and comment on costs and benefits. I argue against approaches involving attacks on Chinese soil and for the reinvigoration of passive defense.

Aggressive Measures to Supplement Active Defense

Given the "home field" advantage that China enjoys in the ballistic missile–vs.–ABM competition, the United States could choose to try to "thin the herd" of missiles that China could effectively fire. Such alternatives deserve analytic scrutiny.

Attacks on Missile Launchers. This approach to reducing the ASBM and CSS-6 threat has some obvious downsides. One involves technical feasibility. China's ASBMs and CSS-6s are fired from mobile transporter-erector launchers. This means that the United States has to find TELs before it can strike them. That is hard to do. In both Persian Gulf wars, the United States was not able to find Scud launchers despite overwhelming air superiority. American aircraft over China would be outnumbered in the air and face numerous surface-to-air missiles, so hunting for TELs would be even harder. The United States might well be unable to diminish substantially China's ASBM inventory advantage by attacking launchers.

Another possible downside involves political constraints. To have the best chance of offsetting China's inventory advantage, the United States would need to attack Chinese launchers before they began firing. However, it is hard to imagine American political leaders granting permission for preemptive attacks against an adversary with nuclear-tipped intercontinental ballistic missiles. When faced with such an adversary during the Cold War, the United States took great care to avoid fighting the Soviet Union directly. It did not conduct attacks on Soviet territory and relied on proxies even when combat occurred elsewhere, like Afghanistan. It is hard to see American political leaders behaving differently as a means of compensating for inadequacies in ABM capabilities. After all, one reason for investing in missile defense is to give political leaders options apart from direct attacks on nuclear-armed adversaries.

Attacks on Chinese Command and Control (C2). Suppose that the United States could deny China the ability to send launch orders promptly once a carrier was identified and located or at least could delay such messages. Doing so would increase the size of the area of uncertainty and thus the number of missiles the attacker would have to fire to be successful. Thus, successful disruption of Chinese C2 might help to offset "Red's" inventory advantage.

Whether C2 attacks would face the same political constraints as launcher attacks depends on the technology employed. If the United States were able to disrupt command and control without kinetic attacks on Chinese soil (e.g., via cyberspace attack), American political leaders might go along. Otherwise, attacks against C2 might encounter the same political resistance as attacks on TELs.

Attacks on Chinese ISR Assets. As noted earlier, one way to decrease the effectiveness of China's ASBM inventory is to increase the size of the AOUs that China's missileers face. Imaginable ways to do so include attacks on Chinese satellites or on OTH radar ashore. As with other "thin the herd" approaches, the feasibility of such attacks depends on both technical and political factors. Advocates of such attacks to compensate for active-defense shortcomings face a substantial burden of proof.

Passive Means of Supplementing Active Defenses

Fortunately, the United States might well compensate for the limits of its active defenses in ways that do not involve the risks just described. Doing so would involve vigorous development and testing of passive defenses and energetic deployment of those that show promise.

The Case for Reinvigorating Passive Defense at Sea. Of course, the fact that active defense is inadequate does not prove that passive defense will work. However, it does mean that if the Navy is serious about possible conflict with China, it should reallocate resources from active to passive defense. The Navy should use increased passive-defense spending to support a rigorous program of hardware development, operational testing, and change in peacetime operating procedures. Such initiatives will permit the United States to assess more accurately the extent to which enhanced passive defense can check the ASBM threat.

Efforts to reinvigorate passive defense at sea would likely include severe radar and communications emissions control, use of decoys and deception emitters, development and deployment of obscurants, and adoption of operational patterns that China would find hard to predict.[50] The United States should not only develop the hardware needed to permit such operations but publicize the fact. Indeed, the nation should consider *pretending* to embrace certain passive defenses, even if they have drawbacks that would make commanders reluctant to use them in wartime.

Reinvigorated passive defense should, of course, increase the area of uncertainty that Chinese systems confront and thus drive up the odds that the ASBM system would prove unable to perform its missions. Even if convincingly pretended rather than genuine, such efforts might also erode Chinese confidence and induce costly investments to restore that confidence. Finally, such initiatives might persuade the Chinese not to launch ASBM attacks in situations where they might otherwise have done so.

Reinvigorated passive defenses will come at a cost. One retired naval intelligence officer puts the point this way:

> It is very demanding to maximize a CVN's [nuclear-powered aircraft carrier's] operational effectiveness while minimizing its signature. Given the advanced sensors that

> China says that it is fielding, the U.S. Navy will have to take countertargeting very seriously—much more seriously than it currently does or did during the Cold War. Rigorous countertargeting will have to be standard operating procedure, not a periodic and half-hearted event that is readily suspended for safety of operations. In particular, sufficiently effective countertargeting operations entail increased casualty and equipment risks in peacetime operations from operating in what is essentially a wartime mode. If the U.S. Navy is going to operate ships within the range arc of these advanced missiles and their targeting sensors, it must fully train for it, invest heavily in passive defense/countertargeting systems, and be ready to accept increased risk and potentially higher peacetime loss rate (both people and equipment).[51]

Of course, the United States could continue to spend money as planned and to shortchange passive defense. Unfortunately, the result might well be to make U.S. carriers far more vulnerable than they would be if we allocated our efforts differently.

The Case for Enhanced Passive Defense of Air Bases Ashore. Military-spending advocates often argue that only real capability deters a serious opponent. If that is true, the United States needs to assess the prospects that increased efforts at passive defense would enable air bases like Kadena to survive determined and repeated Chinese attacks.[52] Of course, passive defense of (inherently fixed) land bases is in critical respects more difficult than passive defense of (inherently mobile) ships. So it is entirely possible that passive defense investments would pay off at sea and fail ashore.

That said, what kinds of passive defense investments should the United States consider, if it is serious about using the U.S. Air Force in a conflict with China? (Indeed, if it does not take that prospect seriously, why does it need the F-22?) Several deserve mention.

- RAND reports "weakly protected fuel storage" at Kadena; the United States should evaluate the costs and payoffs of various fixes.[53]
- The United States should consider building additional hardened shelters for fighters. If it fails to do so, relatively modest ballistic-missile investments would enable China to destroy large numbers of extremely costly F-22s.
- If U.S. intelligence concludes that Chinese CSS-6s are sufficiently accurate to sever runways with modest numbers of warheads, the United States should evaluate the costs and benefits of having enough rapid-runway-repair kits on hand to restore runways after repeated cratering attacks. Of course, all kits should be able to pass realistic tests—for example, will the concrete "set up" in a timely way during the rainy season?

The vulnerability of big-wing aircraft means the United States should consider unorthodox alternatives. For example, it should evaluate whether to build hardened shelters for the E-2D Advanced Hawkeye, a twin-engine turboprop aircraft, and buy E-2Ds for land-based use. Although they are normally based on carriers and are in some respects inferior to the land-based E-3 AWACS, folding-wing E-2Ds can do something that an E-3 cannot do if caught on the ground by a ballistic-missile attack—occupy a shelter and survive a cluster-munition bombardment.

But does a cost-effective substitute for big-wing tankers exist? This issue deserves analytic scrutiny, in light of the Chinese ballistic-missile threat to U.S. air bases in Korea and Japan. Attacks on these bases (or denial of permission to use them) could mean that U.S. tankers would have to operate from Guam, 1,565 kilometers from the Taiwan Strait. Even massive investments in larger tanker fleets to operate from Guam might not solve the problem. China could respond to such developments by developing the means (e.g., ballistic missiles, or cruise missiles from submarines) to attack "big wings" on Guam.

If Chinese ballistic-missile threats to U.S. carriers and air bases evolve along the lines described above, the United States needs to compensate for the shortcomings of active defense. Certain kinds of attacks might "thin the herd" of threatening missiles; others involve prohibitive risks.

Passive defense efforts appear more promising, especially in helping carriers survive. Even so, the vulnerability of big-wing aircraft may prove an insoluble problem. If so, destruction of tanker aircraft would reduce the effectiveness of both carrier fighter-bombers and land-based ones.

In the worst case, a rigorous program of hardware development, changes in peacetime operations, and operational testing might lead the United States to conclude that reinvigorated passive defense cannot adequately offset the inadequacy of active defense. Such an outcome would not mean that the future is hopeless. It would mean that the United States should consider a broader menu of alternatives. For example, the nation might respond by stepping up efforts to develop very-long-range, stealthy, carrier-based unmanned combat aircraft, as suggested by Thomas Ehrhard and Robert Work.[54] Or it might help Taiwan develop a "porcupine defense," as suggested by William Murray.[55] That approach might well enable Taiwan to hold out for several months or longer, even if sudden Chinese missile strikes put its air force and navy out of action. The United States might pursue both these alternatives and develop others equally promising.

Strategy involves weighing costs and benefits. Given the increased costs and risks implied by China's emerging missile forces, the United States needs to consider more broadly how best to protect its interests in the western Pacific. More of the same—active defense—is unlikely to work.

NOTES

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1. "With the emergence in China of a robust area-denial force of great range . . . the time has again come to talk about sea control." Robert C. Rubel, "Talking about Sea Control," in this issue.
2. See, for example, Andrew S. Erickson and David D. Yang, "Using the Land to Control the Sea? Chinese Analysts Consider the Antiship Ballistic Missile," and Eric Hagt and Matthew Durnin, "China's Antiship Ballistic Missile: Developments and Missing Links," both *Naval War College Review* 62, no. 4 (Autumn 2009).
3. For a good overview of the systems that constitute China's "maritime battle network," see Thomas Ehrhard and Robert Work, *Range, Persistence, Stealth, and Networking: The Case for a Carrier-Based Unmanned Combat Air System* (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2008), pp. 197–201.
4. For a refreshingly original argument that China's ASBM program mainly threatens "carrier-like vessels" operated by other western Pacific navies, see Craig Hooper and Christopher Albon, "Get Off the Fainting Couch," U.S. Naval Institute *Proceedings* (April 2010). Hooper and Albon also are unusual in emphasizing the fact that China has not yet conducted at-sea tests of the system. Most other analysts seem sure that China will soon have an ASBM that works.
5. "Chinese doctrinal writings clearly indicate that the American presence in Japan would likely be the subject of attack if the United States were to intervene in a cross-strait conflict." Toshi Yoshihara, "Chinese Missile Strategy and the U.S. Naval Presence in Japan," *Naval War College Review* 63, no. 3 (Summer 2010), pp. 46–47. Dr. Yoshihara's article "focuses narrowly on Chinese assessments of U.S. naval bases in Japan, excluding the literature on such other key locations as . . . Kadena" (p. 40). Even so, the use of ballistic missiles that I discuss fits well the mind-set he describes.
6. As detailed later in this article, China would need to reduce the CSS-6 payload somewhat to extend its range sufficiently to reach Kadena. See note 12.
7. Context makes clear that Admiral Walsh was using "missile defense" as this phrase is typically used—to refer to active missile defenses like Aegis BMD. The full text of the relevant passage from the Japanese newspaper *Asahi Shimbun* reads: "When asked how much of an actual threat China's anti-ship ballistic missiles (ASBMs) pose to the U.S. Navy, he did not answer directly, saying only, 'I think it represents a continued advancement and maturing of technology.' He added: 'If you remember, there were many, several years ago, who were critical of the missile defense program. Now we find the missile defense program as being something that's essential to our ability to operate freely.'" See Yoichi Kato, "U.S. Commander Blasts Chinese Navy's Behavior," *Asahi Shimbun,* 16 June 2010.
8. Surprisingly, the open-source literature does not contain much evidence that either Chinese or American analysts have compared projected ASBM and ABM inventories and noticed China's numerical advantages.
9. For a discussion of costs in an ASBM-vs.-SM-3 competition, see Thomas Culora, "The Strategic Implications of Obscurants," *Naval War College Review* 63, no. 3 (Summer 2010), pp. 74–75.
10. The P-8 Poseidon, slated to replace the P-3, is also too large to shelter. AWACS is based on the E-3 Sentry aircraft, which is a modified Boeing 707; the P-3, a four-engine turboprop

aircraft, is a modified Lockheed Electra airliner.

11. Kadena and aircraft based there might prove unavailable for reasons apart from a successful CSS-6 attack. For example, cruise missiles pose another potential threat to unsheltered aircraft. (For more detail on that threat, see John Stillion and David Orletsky, *Airbase Vulnerability to Conventional Cruise-Missile and Ballistic-Missile Attacks* [Santa Monica, Calif.: RAND, 1999], pp. 15–17.) Of course, the all-too-plausible prospect that Kadena and other Japanese bases will not survive to make a difference in U.S.-Chinese combat over Taiwan raises a political uncertainty. In combination with other factors, this prospect may lead Japan to deny the United States permission to use its bases.

12. The CSS-6 delivers a 500 kg payload at a range of 600 km. The distance from Kadena to the closest point in mainland China is about 640 km. So Chinese missileers will have to reduce the payload somewhat to extend the CSS-6's range. For an analysis of trading off payload to increase ballistic-missile range, see R. L. Pope, R. D. Irvine, and S. J. Retallick, *Range/Payload Trade-Offs for Ballistic and Cruise Missiles,* DSTO-RR-0025 (Canberra: Australian Department of Defence, n.d.). Extrapolating from that article, I estimate that cutting the CSS-6 payload by about 12 percent will increase its range to 666 km.

13. These analyses include the already-cited papers by Ehrhard and Work, Erickson and Yang, and Hagt and Durnin. See also Mark Stokes, *China's Evolving Conventional Strategic Strike Capability* (Arlington, Va.: Project 2049 Institute, 14 September 2009).

14. SIGINT involves interception of communications, radar, and other forms of electromagnetic transmissions. Subcategories of SIGINT include ELINT and COMINT (communications intelligence).

15. When operating under EMCON military units, such as carriers, restrict their electronic emissions to a certain level in order to "hide" from others' SIGINT assets.

16. Hagt and Durnin, "China's Antiship Ballistic Missile," p. 94.

17. Ibid., p. 95.

18. Ehrhard and Work, *Range, Persistence, Stealth, and Networking,* p. 200.

19. Hagt and Durnin, "China's Antiship Ballistic Missile," p. 105.

20. Ibid., p. 91.

21. Ibid., pp. 92–93.

22. Ibid., p. 89.

23. Ibid. Stokes says that "the DF-21D, a 1,500 to 2,000 km range ASBM [,] . . . could be available to the PLA by . . . 2010." Stokes, *China's Evolving Conventional Strategic Strike Capability,* p. 9.

24. DoD's annual report *Military Power of the People's Republic of China* uses the term "CSS-5" to denote China's DF-21 missile. Its 2005 report (p. 45) says that China had from nineteen to twenty-three CSS-5s; its 2009 report (p. 66) says sixty to eighty. These ranges imply production of as many as sixty-one (80 – 19) or as few as thirty-seven (60 – 23) over four years, or from nine to fifteen per year.

25. Mark Stokes cites an "unconfirmed" Chinese source that anticipates deployment of 204 ASBMs. These would equip two DF-21 ASBM brigades, each brigade having six battalions with seventeen launchers apiece. Stokes, *China's Evolving Conventional Strategic Strike Capability,* p. 29.

26. Secretary Gates announced the goal of twenty-four Aegis BMD ships in April 2009. (See "DoD News Briefing with Secretary Gates from the Pentagon, April 6, 2009," Defenselink.mil.) More recently DoD has mentioned a total of twenty-one to thirty-two BMD-capable ships; U.S. Defense Dept., *Quadrennial Defense Review Report* (Washington, D.C.: February 2010), p. 46.

27. The Navy plans to improve the SM-3 over time. To date, it has bought Block I and IA SM-3s. It will next take delivery of Block IB missiles, which, according to the Missile Defense Agency, "will more readily distinguish between threat re-entry vehicles and countermeasures." (Lt. Gen. Henry Obering, statement before the Senate Armed Services Committee, 110th Cong., 2nd sess., 1 April 2008, p. 15.) At the end of 2015, the Navy will begin accepting delivery of the Block IIA missile. Block IIA missiles are faster and will have some capability against the longer-range intermediate-range and intercontinental

ballistic missiles that Block I missiles cannot hit. (Missile details come from Ronald O'Rourke, *Sea-Based Ballistic Missile Defense* [Washington, D.C.: Congressional Research Service, updated 21 November 2008], pp. 6, 8.)

28. O'Rourke, *Sea-Based Ballistic Missile Defense,* p. 10.

29. The Missile Defense Agency's director mentioned a goal of "approximately 70" SM-2 Block IV missiles in June 2009. See Lt. Gen. Patrick J. O'Reilly, USA, Director, Missile Defense Agency, *[Testimony] Before the Senate Armed Services Committee, June 16, 2009,* 111th Cong., 1st sess., p. 9, available at www.mda.mil/. For the figure of eighty, Rear Adm. Alan B. Hicks, "Aegis Ballistic Missile Defense Overview for the George C. Marshall Institute" (3 August 2009). Slide 10 of this presentation says that the U.S. Navy will "modify 70–80 SM-2 Block IV missiles."

30. Hicks, "Aegis Ballistic Missile Defense Overview for the George C. Marshall Institute," slide 3. The slide contrasts the objective of 147 SM-3 missiles in the FY 2009 "President's Budget" (PB09) with the newer objective of 218 in PB10. The 220 figure includes 218 SM-3 Block I, IA, and IB missiles and two SM-3 Block IIA missiles. In discussing the now-superseded goal of 147 SM-3s by 2015, the Missile Defense Agency's FY 2009 "Budget Estimates Overview" (p. 20) provided additional detail about the SM-3 types that will constitute the first 147 delivered: "The program will still deliver a total of 147 SM-3 missiles, but the first 94 will be Block I/IA missiles, not the 75 as proposed in PB 08."

31. Michael Bennett and Kevin Eveker, *Options for Deploying Missile Defenses in Europe* (Washington, D.C.: Congressional Budget Office [hereafter CBO], February 2009), p. 21. CBO mentioned the seventy-two-missile SM-3 requirement before DoD announced its decision to rely only on sea-based ABMs to counter the Iranian threat. However, CBO assumed seventy-two SM-3s in estimating implementation costs for such a decision. CBO envisioned ten SM-3s aboard six of the nine ships devoted to this mission and an additional twelve as spares. CBO also envisioned using SM-3 Block IIA missiles, which will not enter production until 2015. So it seems safe to assume that at least seventy-two of the less-capable Block I missiles would be required for deployments begun sooner.

32. CBO assumed the Navy would use a modified version of the Littoral Combat Ship for this role. Table 1 reflects the assumption that the Navy would rely on ABM-configured *Arleigh Burke* destroyers and *Ticonderoga* cruisers.

33. Historically, the combat performance of guided missiles has fallen short of what is expected based on peacetime test results. For example, RAND data show that the AIM-7's combat P_k in Vietnam was 0.08, compared to prewar estimates of 0.7. See John Stillion and Scott Perdue, "Air Combat, Past and Future," RAND Corporation Briefing, August 2008, slide 19.

34. Culora, "Strategic Implications of Obscurants," p. 75.

35. Hagt and Durnin, "China's Antiship Ballistic Missile," p. 105.

36. U.S. Defense Dept., *Military Power of the People's Republic of China, 2009* (Washington, D.C.: March 2009), p. 66, says that China has sixty to eighty DF-21s, which DoD calls CSS-5s. The 2008 report (p. 24) says that "upwards of 50" of these missiles are reserved for nuclear missions. If that is correct, China might have as many as thirty (80 – 50) conventional DF-21s available.

37. See Andrew M. Sessler et al., *Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System* (Cambridge, Mass.: Union of Concerned Scientists/MIT Security Studies Program, April 2000), p. 44. This study describes a large number of decoy and penetration-aid strategies for defeating exo-atmospheric interceptors.

38. Stillion and Perdue, "Air Combat, Past and Future," slide 14.

39. The Taiwanese National Ministry of Defense estimates that an SRBM-delivered 500 kg unitary warhead can create a runway crater ten meters deep and twenty meters wide. (See Bernard Cole, *Taiwan's Security: History and Prospects* [London: Routledge, 2006], p. 116.) I assume that such a crater is a cone with depth equal to radius and that displacement from such a warhead is proportional to warhead size. Given those assumptions, I

extrapolate that a 436 kg warhead could produce a crater 9.5 meters wide. Given highly accurate delivery, six such warheads could crater and sever one of Kadena's runways at two different points.

40. This estimate rests in part on two RAND analyses. In their 1999 *Airbase Vulnerability* study (p. 14), John Stillion and David Orletsky estimate that a 500 kg warhead could deliver 825 bomblets for a destruction area nine hundred feet in diameter. In their 2008 "Air Combat" briefing, John Stillion and Scott Perdue state that thirty-four missiles with submunition warheads could "cover all parking ramps at Kadena" and "damage, destroy, or strand 75 percent of aircraft based there" (slide 10). Since I assume a smaller (436 kg) warhead would enable the CSS-6 to reach Kadena, I assume fewer bomblets (721) and a smaller destruction diameter (842 feet). Roughly forty of these smaller cluster warheads would cover the same area as the thirty-four 500 kg ones. See Stillion and Orletsky, *Airbase Vulnerability to Conventional Cruise-Missile and Ballistic-Missile Attacks,* and Stillion and Perdue, "Air Combat, Past and Future."

41. In the late 1970s, the U.S. Air Force argued for buying more F-15s because of the Soviet threat. However, it was reluctant to invest in shelters at the same time, even though unsheltered F-15s on the ground would have been sitting ducks.

42. U.S. Defense Dept., *Program Acquisition Costs by Weapon System: Department of Defense Budget for Fiscal Year 2010* (Washington, D.C.: May 2009), pp. 3–33.

43. DoD's *Military Power* report for 2009 counted 230–270 CSS-6s in 2005 and 350–400 in 2009. These figures imply production of as few as eighty (350 – 270), or as many as 170 (400 – 230), over four years.

44. William Murray describes various ways China might attack PAC radars on Taiwan. It could use similar systems (or develop longer-ranged ones) to do so on Okinawa. William Murray, "Revisiting Taiwan's Defense Strategy," *Naval War College Review* 61, no. 3 (Summer 2008), p. 18.

45. Missile Defense Agency, *The Missile Defense Program* (Washington, D.C.: 3 August 2009), p. 12, available at www.mda.mil/.

46. Ibid., p. 15.

47. China's inventories of missiles capable of being modified to hit Andersen are much smaller than its inventories of CSS-6s. Unless this situation changes, small numbers of THAAD missiles might contribute more to protecting Andersen than they could contribute to protecting Kadena.

48. U.S. Army Dept., *2007 Posture Statement* (Washington, D.C.: 14 February 2007), available at www.army.mil.

49. Craig Whitlock, "Pentagon Resists Army's Desire to Stop Development of MEADS Missile System," *Washington Post,* 9 March 2010.

50. For an imaginative suggestion about how the Navy might exploit relatively cheap Army-developed obscurants to protect ships from missile attack, see Brett Morash, "Naval Obscuration" (Naval War College research paper, Newport, R.I., 21 June 2006). For an assessment of how the United States might benefit from developing and deploying effective obscurants, see Culora, "Strategic Implications of Obscurants," pp. 73–84.

51. Personal communication, 21 September 2009.

52. Continued American failure to make serious investments in Kadena passive defenses might conceivably affect Japan's willingness to permit U.S. combat operations from its soil. Why should Japan offend its nuclear-armed neighbor China if doing so will help the United States only temporarily, until CSS-6s put Kadena out of action?

53. Of course, a thorough analysis of Kadena survivability would have to consider its entire logistics supply chain. Thus, hardened fuel storage ashore might not be a worthwhile investment if China could easily attack the ships used to resupply fuel. Carriers also depend on ships for fuel resupply, but again, carrier mobility makes interdiction much harder for China.

54. See Ehrhard and Work, *Range, Persistence, Stealth, and Networking,* pp. 147–60.

55. Murray, "Revisiting Taiwan's Defense Strategy," p. 13.