AN ASSESSMENT OF THE U.S.-CHINESE RECONNAISSANCE-STRIKE COMPETITION

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Introduction

The United States and China are developing competing complexes for penetrating, precision strike as part of the broader military competition in the Western Pacific.

After the United States' display of aerospace prowess in the 1991 Gulf War, the most perceptive Chinese military thinkers realized that something significant had changed about modern war.[1] China had not fought a major war with the West since Korea, and the Gulf War demonstrated that military size alone was insufficient for repelling a high-tech adversary. Thus, under General Secretary Jiang Zemin, China hastened the replacement of Mao Zedong's "people's war" or "grand army" military model in favor of preparation for "local war under high-tech conditions."[2] China's increasingly formidable reconnaissance-strike force is the modern manifestation of its local-war doctrine.

Although the Chinese reconnaissance-strike complex (RUK) looks very different than the U.S. RUK, both exploit the same military-technological developments.[3] Specifically, RUKs are made possible by progress in guided munitions and advanced targeting networks. At its most basic level, reconnaissance-strike is merely the operational integration of these two technologies.

This paper assesses the competition in reconnaissance-strike between the United States and China. Specifically, it assesses how the interaction of asymmetric reconnaissance-strike complexes shape incentives for future investment in the U.S. and Chinese reconnaissance-strike complexes.

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[1] Mark A. Stokes, *China's Strategic Modernization: Implications for the United States* (Carlisle, PA: Strategic Studies Institute, 1999), p. 12, 21 (n. 15).
[2] Hideaki Kaneda, "A View from Tokyo: China's Growing Military Power and its Significance for Japan's National Security," in Andrew Scobell and Larry M. Wortzel, Eds., *China's Growing Military Power: Perspectives on Security, Ballistic Missiles, and Conventional Capabilities* (Carlisle, PA: Strategic Studies Institute, 2002), p. 65.
[3] From Russian: рекогносцировк-удара комплекс

The remainder of this paper has four sections.

Section I elaborates on reconnaissance-strike as a technological and operational concept. First, it defines the scope of reconnaissance-strike. Then, it contextualizing the phenomenon within the guided weapons revolution. Finally, by discussing milestones in the first two decades of the concept's evolution, it explains how guided weapons and targeting networks are integrated operationally to form an RUK.

After Section I, the next two sections review the competing RUKs under development in the United States and China.

Section II examines the causes and consequences of asymmetry between U.S. and Chinese RUKs. It argues that the Chinese RUK is an asymmetric response to three factors: theater geography, the theater's threshold for military victory, and the overall balance of conventional forces.

Section III takes an operational look at both RUKs. Specifically, it assesses the key variables that determine the efficacy with which each side can carry out its primary reconnaissance-strike skill. For the United States, this skill is the suppression of enemy air defenses. For China, it is the destruction of U.S. aircraft carriers.

Finally, Section IV summarizes the implications for future investment in the U.S. reconnaissance-strike complex.

The paper reaches two major conclusions. First, the progression of sensor technology and the rate at which each side adopts the technology will be the most important technological factor influencing the nature the reconnaissance-strike competition.

Second, the investment incentives drawn from top-level asymmetries—which are responsible for shaping the hardware profiles of the U.S. and Chinese RUK—are highly durable.

I. What is Reconnaissance-Strike?

There is at least one good reason that assessing the reconnaissance-strike competition separate from the general U.S.-Chinese military competition is a worthwhile endeavor. The nature of the reconnaissance-strike competition is such that one military's improvement in a reconnaissance-strike skill will usually adversely affect its adversary's ability to execute reconnaissance-strike skills, both directly and indirectly. Indeed, as reconnaissance-strike cements its position as the dominant form of penetrating strike in the 21st century, RUKs will increasingly become a favored target of competing RUKs.

The latter half of this paper explores these competitive interactions. This section defines the scope of reconnaissance-strike and summarizes its technological and operational heritage.

A. Scope

This paper's introduction defined reconnaissance-strike as the operational integration of guided weapons and advanced targeting networks. For the purposes of this paper, a guided weapon (or guided munition) is a bomb, projectile, or other munition that actively corrects course by homing on its aimpoint during the terminal phase of engagement.[4] Targeting networks can be broken down into sensors and command and control (C2). Advanced targeting networks have advanced sensors, such as wide-angle or long-range sensors.

[4] See Barry D. Watts, *Six Decades of Guided Battle Munitions* (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2007), p. 26-27. The requirement for terminal homing excludes virtually all Cold War era intercontinental and submarine-launched ballistic missiles. As Watts notes, this does not mean that none of these missiles had internal guidance systems. See Donald MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge, MA: MIT Press, 1993).

Not all weapons systems that make use of targeting networks and guided munitions are reconnaissance-strike systems. Reconnaissance-strike systems must be penetrating. In other words, they must generally hit targets beyond the forward edge of the battle area. Put another way, RUKs are generally capable of executing offensive strike missions. This is an important distinction, because it means that most air defenses are not considered part of the Chinese RUK (nor missile defense part of the U.S. RUK), even though they may integrate guided weapons with advanced targeting networks.

At first, this distinction may seem hard to justify. After all, air defense often have an operational effect similar to land-attack cruise missiles (LACMs)—which *are* part of the Chinese RUK. Both systems are capable of executing missions that eliminate enemy aircraft; the former accomplish this mission when the target is in the air, the latter when the target is on the runway. Thus, it might seem that the difference between offense and defense is manufactured.

It makes a real difference, though, whether the engagement decision is made by U.S. aircraft or China's missiles. To be sure, this is a blurry line, since modern air defenses often have ranges exceeding those of early-generation LACMs. For this reason, China's S-300 class of integrated air defenses (IADS) is often discussed in concert with the Chinese RUK, even though its membership in this architecture of systems is debatable.

B. The Guided Weapons Revolution

Unlike major military competitions in the twentieth century, the reconnaissance-strike competition—now nearly two decades old—remains driven by the leading edge of technology.

The competition in mobile armor, which took place primarily on the European continent, began in World War I and continued throughout the Cold War. The competition in nuclear arms, which began in 1949 with RDS-1, the first Soviet nuclear weapons test, also continued until the

Soviet collapse. Both Cold War competitions were driven more by each side's production potential than by technological potential.

The evolution of reconnaissance-strike has been, and will continue to be, determined by advances in two categories of military hardware: guided munitions and advanced sensors. When these technologies are tethered with rapid-reaction C2, the result is what the Soviets called a reconnaissance-strike complex. More specifically, the Soviet RUK concept envisioned wide-area or long-range sensors and guided weapons delivered by missile or strike aircraft, both linked to automated C2.[5]

The guided weapons revolution has had two effects on modern operations. First, it made precision the defining characteristic of munition application. From World War I through the early 1940s, the inability to correct aiming errors made increasing ordnance mass the only real substitute for inaccuracy.[6] By the end of World War II, the emergence of electro-optical, infrared, and heat-seeking munitions marked the beginning of the guided weapons revolution.[7]

The early stages of guided weapons development, though, were overshadowed by the nuclear revolution. The enormous destructive power of nuclear weapons made mass and precision secondary to warhead yield. Precision did not become a dominant consideration until Vietnam, when the United States developed the need to conduct effective, high-frequency operations from the air with limited collateral damage. With precision the most important characteristic of force application, the United States began to field laser-guided bombs with circular error probabilities (CEP) of roughly 300 feet—highly impressive for the period.[8]

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[5] Notra Trulock, III, Kerry L. Hines, and Anne D. Herr, *Soviet Military Thought in Transition: Implications for the Long-Term Military Competition* (Arlington, VA: Pacific-Sierra Research Corporation, 1988), p. v.
[6] Watts, 2007, p. 259.
[7] Randy L. Kaufman, "Precision Guided Munitions: History and Lessons for the Future," Master's thesis, School of Advanced Air and Space Studies, June 2004, p. vii.
[8] Kaufman, 2004, p. 2.

The second effect of the guided weapons revolution is increased projectile range, resulting in a greater potential for stand-off strike. The guided weapons revolution has now made accuracy largely independent of range to the target.[9] As a military begins to increase stand-off strike distance, though, the marginal increase in available targets per each additional mile of distance begins to drop sharply. Targeting networks are the solution. In the words of Barry Watts, a former acolyte of Andrew Marshall and one of the foremost public writers on reconnaissance strike, precision munitions require precision information.[10]

The revolution in guided weapons, which had been making slow and steady progress since the 1940s, entered a period of maturation during the 1990s, the harbinger of which was the Persian Gulf War. This trend has persisted over the last two decades.

Since 1990, for instance, the lethality of submarine-launched cruise missiles against very hard targets (over 2000 psi) has roughly quadrupled, holding yield constant.[11] The accurate GBU-28 and the highly accurate Tomahawk IV were both developed after the Cold War ended. Lower CEPs raise the single shot probability of kill (SSPK) of many conventional warheads to levels approaching or equal to the SSKP of most Cold War nuclear weapons. In fact, directing a volley of cruise missiles at a re-enforced silo has become a feasible alternative to using nuclear weapons for the same mission—one of the principle insights that motivated early American writers on RUKs, such as Albert Wohlstetter.

[9] Watts, 2007, p. xiv.
[10] Watts, 2007, p. ix.
[11] Bruce Blair, Eric Hundman, and Haninah Levine, "Conventionalization of Strategic Forces: Single Shot Probability of Kill (SSPK) Analysis of Conventional Munitions for Strategic Targeting," Draft, World Security Institute, Oct. 12, 2006.

Table 1. Single-Shot Probabilities of Kill for Several Guided Munitions[12]

Hardness (psi)	1.45	2.9	14.5	43.5
		parked aircraft	radar installation	reinforced concrete
CEP (ft)				
Tomahawk IV				
10	1.000	1.000	1.000	0.997
15	1.000	1.000	0.996	0.922
25	1.000	0.998	0.863	0.602
Conventional Trident II (D5)				
30	0.991	0.947	0.617	0.356
50	0.820	0.652	0.290	0.147
GBU-28				
25	1.000	0.997	0.843	0.576
30	0.998	0.981	0.724	0.449
AMG-86 ALCM C				
10	1.000	1.000	1.000	1.000
20	1.000	1.000	0.994	0.908

0.xxx (black)	indicates SSKP ≥ 0.750
0.xxx (grey)	indicates 5-shot KP ≥ 0.750

Table 1 shows SSKPs for four guided weapons in the U.S. RUK—the Tomahawk IV cruise missile, the conventional Trident II (D5) ballistic missile (under development/possibly operational), the GBU (Guided Bomb Unit)-28, and the AGM-86C/D Conventional Air-Launched Cruise Missile—given varying targets and assumptions about CEP.[13] The important point to take away from the table is that even low SSPKs can indicate an acceptable target for

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[12] Adapted from a similar chart in Bruce Blair, Eric Hundman, and Haninah Levine, "Conventionalization of Strategic Forces: Single Shot Probability of Kill (SSPK) Analysis of Conventional Munitions for Strategic Targeting," Draft, World Security Institute, Oct. 12, 2006. Bolded and underlined CEPs represent best-guess predictions. This table deviates slightly from Blair's CEP predictions, especially for the AMG-86. Displayed CEP predictions the result of analysis done in Andreas Parsch, "Boeing AMG-86 ALCM," *Encyclopedia Astronautica*, accessed online at [http://www.astronautix.com/lvs/alcm.htm]. Five-shot kill probabilities are derived by considering each single shot as statistically independent events. More advanced methods of calculating multiple shot kill probabilities can be found in Frank McNolty, "Kill Probability for Multiple Shots," *Operations Research* 15, no. 1 (January-February 1967), pp. 165-169.

[13] On April 11, 2010, Secretary of Defense Gates seemed to indicate that the D5 had reached initial operating capability: "We have, in addition to the nuclear deterrent today, a couple of things we didn't have in the Soviet days… And we have prompt global strike affording us some conventional alternatives on long-range missiles that we didn't have before." See "'Meet the Press' Transcript for April 11, 2010," p. 3, accessed online: [www.msnbc.msn.com/id/36362669/ns/meet_the_press/page/3/].

guided weapons because multiple bombs or missiles (even dozens) can be assigned to the same target. In other words, mass can be used to supplement precision. This is illustrated by the table's notation of five-shot probabilities of kill.

C. Early Models for Reconnaissance-Strike

The integration of key technologies is as least as important to reconnaissance-strike as the development of those technologies. This subsection explores early attempts to integrate guided weapons with targeting networks.

In the early 1970s, the Defense Advanced Research Projects Agency (DARPA) began a highly-classified study of how the military might leverage several emerging technologies. The *Long Range Research and Development Planning Program* (LRRDPP) was initiated by DARPA (originally ARPA) Director Stephen Lukasik and Fred Wikner, who informally represented the Defense Nuclear Agency. Lukasik believed that the United States might be on the cusp of a military technological revolution similar in importance to the nuclear revolution. Wikner, a former scientific advisor to General Creighton Abrams, played a part in ushering into the battlefield early forms of guided weapons.[14]

LRRDPP brought an analytic team together with industry partners to examine potential military applications of "autonomous-terminal homing…, planned global positioning system satellites, and anticipated improvements in micro-computing and information-processing," among other emerging technologies.[15]

LRRDPP produced more than just an assessment of emergent technologies. The LRDPP's summary report provided considerable detail for seven weapons system concepts,

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[14] Robert Zarate, "Introduction: Albert and Roberta Wohlstetter on Nuclear-Age Strategy," in Robert Zarate and Henry Sokolski, Eds., *Nuclear Heuristics: Selected Writings of Albert and Roberta Wohlstetter* (Carlisle, PA: Strategic Studies Institute, 2009), p. 53.
[15] Zarate, 2009, pp. 52-53.

nuclear and nonnuclear.[16] Figure 1 depicts LRRDPP's concept for an unmanned aerial vehicle (UAV) with "reconnaissance, surveillance, missile strike, and kamikaze capability." The UAV's (referred to in the LRRDPP as an RPV, or remotely-piloted vehicle) concept of operations was to launch, fly several hundred miles, suppress enemy air defenses with stand-off guided weapons, proceed to target, and collide with the target.[17]

LRRDPP's RPV concept meets the requirements of a reconnaissance-strike system. The guided weapons requirement is satisfied with an armament of air-to-ground Maverick-class missiles. Additionally, two 1,000 pound high explosive warheads make the RPV a guided collision weapon. Microwave and long-wave infrared sensors qualify as advanced sensors, since they are all-weather and high-resolution. Finally, the requirement for C2 integration is satisfied with a two-way data link that transmits target images and steering commands. At longer ranges, this data is transmitted through high-altitude aircraft or satellite.

The RPV concept was fairly revolutionary in that it anticipated the merging of several guided weapons technologies. The RPV is essentially a cruise missile capable of dispensing submunitions at distance. The concept is arguably the forbear of the BGM-109D Tomahawk Land Attack Missile – Dispenser (TLAM-D), which dispenses 166 combined-effects bomblets dispersed in 24 packages.[18] As the TLAM-D did not reach operational evaluation until 1988, LRRDPP's RPV concept was more than a decade ahead of its time.

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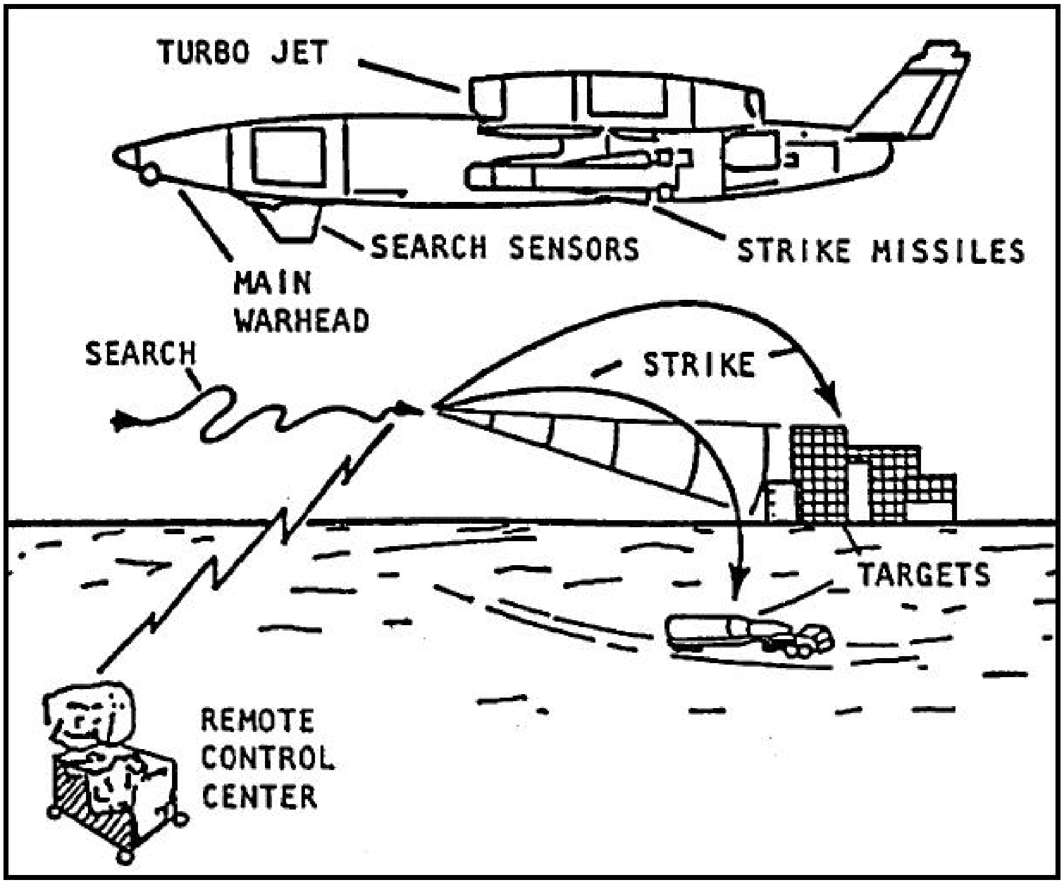
[16] D.A. Paolucci, "Summary Report of the Long Range Research and Development Planning Program (Draft)," (Falls Church, VA: Lulejian & Associates, Feb. 7, 1975), pp. 29-43.
[17] Paolucci, 1975, p. 30.
[18] Combined-effects: armor piercing, fragmentation, and incendiary. For concept discussion, see Office of Technology Assessment, *Monitoring Limits on Sea-Launched Cruise Missiles* (Washington, DC: Government Printing Office, 1992), p. 28.

Figure 1. LRRDPP Concept for a UAV RUK[19]



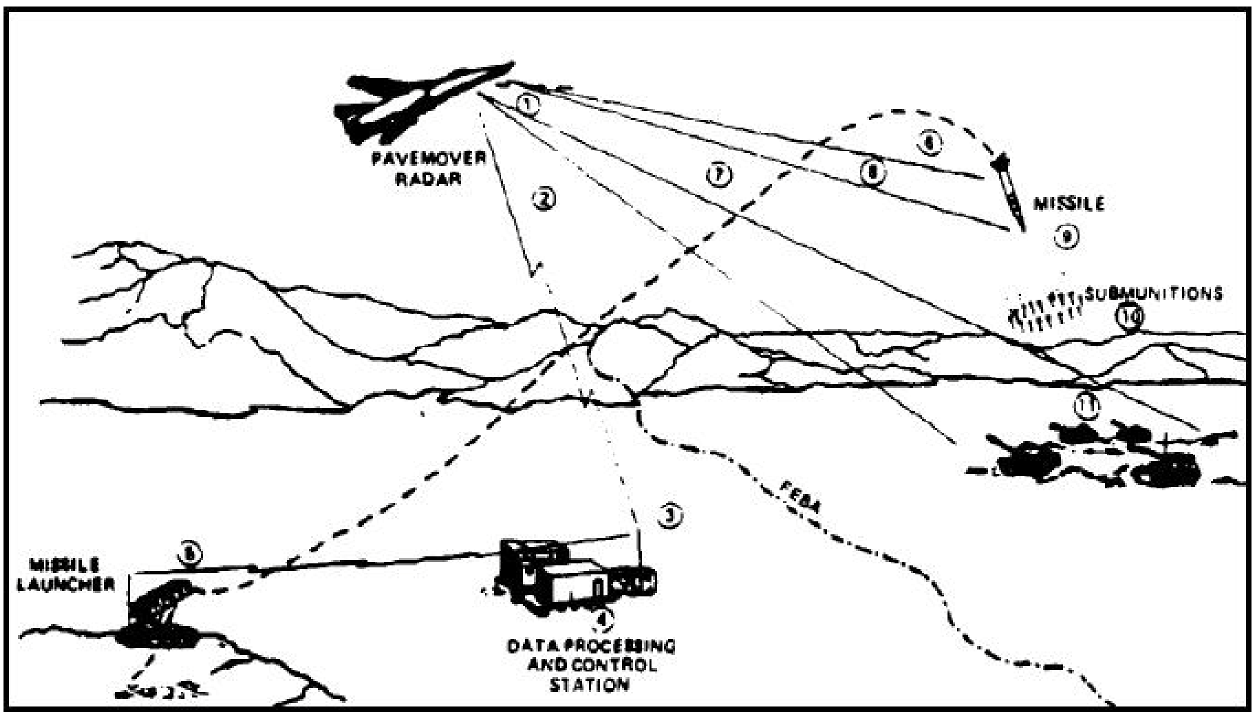
In 1978, while serving as Undersecretary of Defense for Research and Engineering, William Perry established the Assault Breaker project to further explore the applications suggested in LRRDPP.[20] Assault Breaker's concept was to integrate new guidance technologies, such as the Pave Mover radar, with a variety of air-to-ground and ground-to-ground strike options.

Assault Breaker called for "using standoff weapons to attack moving, rear echelon armor massed deep behind enemy lines."[21] Such a concept represented the trifecta of the RUK: (1) precision strike (2) behind enemy lines (3) against mobile targets. At the time DARPA began

[19] Source: Paolucci, 1975., p. 30. Image cleaned by author.
[20] Watts, 2007, p. 11.
[21] Source: Comptroller General of the United States, "Decisions to be Made in Charting Future of DOD's Assault Breaker," Report to the Congress, Feb. 28, 1981, p. i.

research into Assault Breaker, the only non-nuclear option for destroying this type of target set was tactical aircraft.[22] Assault Breaker, though, was a major leap forward in that it was a concept for stand-off strike. The program was to involve "using an airborne radar; airborne or surface launchers; strike missiles with submunition dispensers; self-guided submunitions that are dispensed over the target; and a communications, command, and control network to link the target acquisition, data transmission, and strike functions."[23]

Figure 2. Standard Assault Breaker Concept[24]



Assault Breaker illustrated the possibilities of linking guided weapons and sensors with a common network. The sequence of operations for Assault Breaker was as follows:

> The [PAVE MOVER] radar aircraft orbits behind the forward edge of the battle area and (1) surveys a designated area. (2) Radar data are transmitted to a data processing control station on the ground where it is (3) processed and analyzed for potential targets. These data are (4) used by the battlefield commander to

[22] Comptroller General, 1981, p. 1.
[23] Comptroller General, 1981, p. 1.
[24] Comptroller General, 1981, p. 1.

> formulate engagement decisions. Once the engagement decision is made, the radar tracks the targets, and (5) missiles are launched. The missile (6) flies to the submunition dispense point. For moving targets, the radar (7) tracks the missile and target before the submunitions are dispensed and (8) provides updated positions to the missile. At the dispense point, the missile (9) releases its submunitions over the target array. The submunitions then (10) acquire and (11) fly to the targets, and detonate their warheads.[25]

This sequence of events is depicted in Figure 2. As with any RUK, Assault Breaker was driven by technological progress in a combination of: (1) munitions and munition delivery (i.e., platforms), (2) sensors, and (3) networks. Thus, even though most of the programs that were spawned by Assault Breaker were eventually canceled, the initial concept of networking platforms and sensors is common in all modern incarnations of the RUK.

[25] Comptroller General, 1981, p. 1.

II. Asymmetry

The United States and China have developed fundamentally different RUKs. Specifically:

- They emphasize development of fundamentally different categories of hardware systems. The U.S. RUK is platform-dominant, while the Chinese RUK is projectile-dominant.
- Each RUK has a different set of critical skills it must be able to accomplish.

In order to understand the competition between U.S. and Chinese RUKs, it is necessary to have a thorough understanding of how asymmetric RUKs originate and the unique effect they each have on operational art. As will be demonstrated in this and the next section, the first asymmetry is largely responsible for the second.

Although tempting, is not accurate to argue that the U.S. RUK is determined by its intended missions. Reconnaissance-strike missions take place in the context of the theater's correlation of forces, which is at least in part determined by what the enemy decides to build. In other words, U.S. reconnaissance-strike missions are limited by the target set provided by China. Stating that the hardware profile of the U.S. RUK is determined by the RUK's primary missions begs the question of *why* the Chinese constructed the specific force targeted by the United States. This paper takes the view that the skeleton for each RUK is shaped by durable, strategic-level factors.

This section's basic argument is that the reconnaissance-strike profile preferred by both countries is the result of three factors: theater geography, the threshold for military victory, and the overall balance of conventional forces. Each factor is addressed sequentially. Section III will look more closely at the concept of operations allowed by each RUK; this section addresses the first half of the puzzle: the origination of asymmetric RUKs.

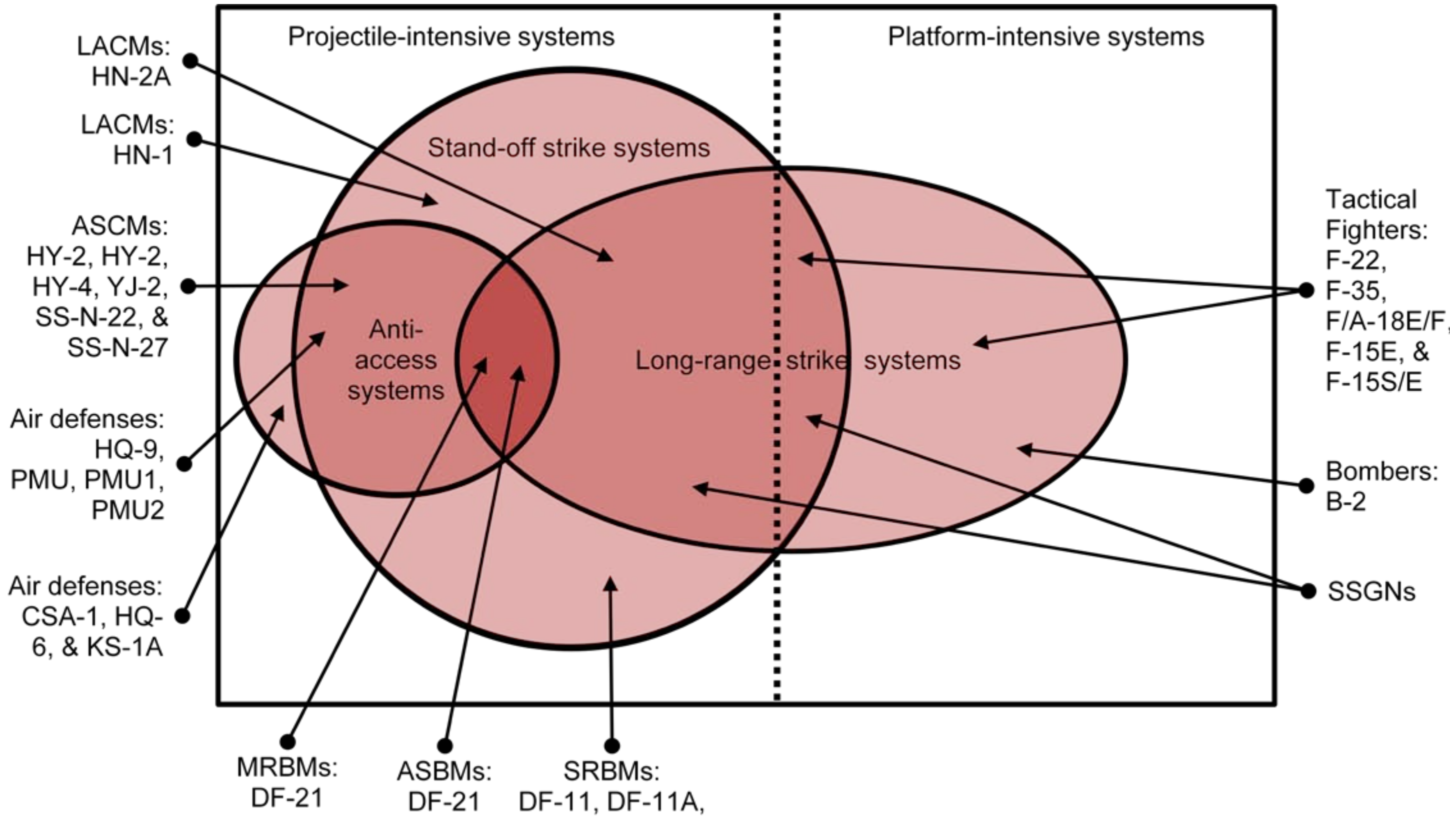
This section introduces several important concepts.

- *Platform-intensity* is a measurement of the importance a platform relative to the importance of a munition in a given weapons system. It is defined by the distance-to-target covered by the platform divided by the distance-to-target covered by the munition after it is released from the platform.[26] Platforms can be as complicated as a guided missile submarine or as simple as a ballistic missile transporter-erector-launcher (TEL).
- *Long-range strike* is defined as a strike mission that exceeds 1,000 miles, measured from the point of platform departure to the point of munition impact.
- *Stand-off strike* is not synonymous with long-range strike; the degree of stand-off strike is determined solely by the distance covered by the munition (in the case, a projectile) relative to the range of the target's primary defense mechanism. As applied in this paper, stand-off strike is a sliding scale—as opposed to a category with clear parameters.
- The most comprehensive study of the effect of *anti-access* capabilities on the U.S. military defines anti-access strategies as those that "aim to prevent U.S. force entry into a theater of operations."[27] This paper takes a narrower view, defining anti-access at the level of weapons systems. Specifically, anti-access systems conduct stand-off defensive strike. Even more specifically, an anti-access system uses stand-off strike to attack offensive-strike platforms.

The relationship between these concepts is illustrated in Figure 3 (Chinese systems on left; U.S. systems on right).

[26] Unless otherwise noted, distance is measured on a two-dimensional XY field.
[27] Andrew Krepinevich, Barry Watts, and Robert Work, *Meeting the Anti-Access and Area-Denial Challenge* (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2003), p. 5.

Figure 3. Relationships of U.S. and Chinese RUKs[28]



[28] Point-based air defense included to provide example of non-stand-off, projectile-intensive strike.

A. First Order Cause: Theater Geography

The United States projects power in the Western Pacific through a network of regional ports and airfields. As Table 2 show, U.S. forward operating bases (FOBs) in the Pacific theater are overwhelming concentrated in South Korea and Japan.

Table 2. U.S. Navy and Air Force Forward Operating Bases

	U.S. Navy	Type	Comments	U.S. Air Force	Comments
Hawaii	Barking Sands	NAS/AF		Bellows AFS	
	Pearl Harbor	NS/B; NSY		Hickam AFB	
	NCTAMS EASTPAC	NSF			
	Kaneohe Bay	MCB/AS			
	Camp Smith	MCB/AS			
Japan	Atsugi	NAS/AF		Kadena AB	part of Okinawa complex; largest air power hub in Pacific
	Misawa	NAS/AF	only combined, joint service installation in WESPAC	Misawa AB	only combined, joint service installation in WESPAC
	Okinawa	NS/B; MCB/AS	major site: 10 Marine Bases + Kadena	Yokota AB	
	Sasebo	NS/B			
	Yokosuka	NS/B			
	Iwakuni	MCB/AS			
South Korea	Chinhae	NS/B		Kunsan AB	
				Osan AB	most forward deployed major air base; administers 5 other air bases
				Pusan AB	
				Sachon AB	
				Yechon AB	

Diego Garcia	NSF		Diego Garcia "Camp Justice"
Guam	NSF	includes Apra Harbor and other facilities	Andersen AFB, Guam

NAS/AF=Naval Air Stations and Air Facilities
NS/B= Naval Stations and Naval Bases
NSF=Naval Support Facility
NSY=Naval Shipyards
MCB/AS=Marine Corps Air Stations and Bases

Other Facilities	Comments
Wake Island	Army launch-support facility operated under caretaker permit by USAF; primarily provides logistics support
Saipan	-
Tinian	-
Palau	minimal U.S. presence; Navy Seabee team
Kwajalein	Army ballistic missile defense test site; supports Deep Space operations

There are two reasons that U.S. reliance on Japan and South Korea for its forward posture is a cause for concern. First, due to the host-nation political concerns, it is unclear whether the United States would be able to conduct high intensity operations from these bases. More importantly, any base within the first island chain is vulnerable to a much higher density barrage of cruise and ballistic missiles. This point is illustrated in Table 3, which shows the range from mainland China of several important U.S. FOBs and forward-operating locations; Table 4, which shows the quantity of various land-based theater missiles in the Chinese arsenal; and Table 5, which illustrates the relationship between projectile range, projectile quantity (potential density), and the strength of the anti-access effect.

Table 3. Distance from China of Major U.S. Forward Locations

Select East Asia Bases of Operation	Distance from mainland China
Korea (Osan)	250 miles
Japan (Kadena)	400 miles
Philippines (Subic Bay)	700 miles
Palau	1,600 miles
Guam	1,875 miles
Diego Garcia (out of theater)	2,650 miles
Hawaii (Hickam AFB)	4,150 miles

The scarcity of dry land, combined with the growing threat posed by Chinese theater missiles to FOBs in the first island chain, cause the U.S. RUK to prioritize sea-based systems—which allow the United States to exploit maritime depth—and long-range systems that are capable of operating from increasingly distance bases.

The influence of geography on China's RUK is nearly the opposite. While the United States is a maritime power, China is a continental power, and it has strong incentives to develop land-based systems that exploit its continental depth.

The major advantage of continental depth is the potential for dispersal, which is facilitated by China's most enduring advantage: access to interior lines of communication on the continent.[29] Soviet theorists during the 1980s argued that if dueling countries both possessed RUKs, war would be determined by the side most capable of dispersing its own forces and exposing its opponent's.[30] There are two general reasons that dispersal is valuable in reconnaissance-strike warfare.

First, dispersal can provide added early warning against first strikes. Albert Wohlstetter, one of the first to write about dispersal in the missile age, argued the following: "[I]f the dispersed bases are within a warning net, dispersal can help to provide warning against some sorts of attack, since it forces the attacker to increase the size of his raid and so makes it more

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[29] Lawrence Spinetta, "'The Malacca Dilemma'—Countering China's String of Pearls with Land-Based Airpower," thesis presented to the School of Advanced Air and Space Studies, Air University, 2006, pp. 22. Also, Harold Brown, Joseph Prueher, and Adam Segal, *Chinese Military Power* (New York: Council on Foreign Relations, 2003), p. 3.

[30] Stuart Koehl, "Forward Defense: And the 'Hama Rules,'" *The Weekly Standard*, Dec. 20, 2007, accessed online: [www.weeklystandard.com/Content/Public/Articles/000/000/014/497qscsz.asp?pg=1].

liable to detection…"[31] In twenty-first century warfare, dispersed bases within close proximity benefit from shared over-the-horizon radar coverage. For example, the AN/TPS-71 Relocatable Over the Horizon Radar can cover a 64 degree wedge at ranges over 500 miles and less than 1,600 miles.[32]

Second, dispersal leads to a greater intelligence, surveillance, and reconnaissance (ISR) and logistics burden on the adversary by increasing the "problem of coordination."[33] Simply, forcing the enemy to attack many discrete sites increases the complexity of the operation. Of course, conducting dispersed operations is also associated with coordination difficulties. The primary implication is that dispersed militaries require better C2. Nevertheless, the ISR burden is far greater when attacking a dispersed force than when conducting operations with a dispersed force, for the simple reason that a dispersed military requires only C2 to know the location of its own forces. Adversaries, on the other hand, require high performance from full targeting networks.

B. First Order Cause: The Threshold for Military Victory

China's interest in the Western Pacific is different from that of the United States. U.S. regional goals include protecting the region from domination by a single power, defending strategic lines of communication, protecting allies, and—most generally—preserving its own freedom of action. The last goal—freedom of actions for U.S. forces, is the standard by which both sides would define victory in a U.S.-China war.

[31] Albert Wohlstetter, "The Delicate Balance of Terror," Writings of Albert Wohlstetter, P-1472, RAND Corporation (Nov. 6, 1958; revised Dec. 1958), accessed online at: [http://www.rand.org/about/history/wohlstetter], citation under section "IV: The Delicacy of the Balance of Terror."
[32] "AN/TPS-71 ROTHR (Relocatable Over-the-Horizon Radar," *Weapons of Mass Destruction (WMD)*, Global Security, accessed online at: [http://www.globalsecurity.org/wmd/systems/an-tps-71.htm].
[33] Wohlstetter, 1958, citation under section "V: Uses and Risks of Bases Close to the Soviets."

In a war with the United States, China's threshold for victory is the ability to restrict U.S. freedom of action. From the Chinese perspective, U.S. forces within the second island chain constitute a credible threat against the Chinese mainland. Thus, the Western Pacific as a geographic entity has strategic value to the United States; that is, it is not just a battlespace, but the stage from which it conducts operations and projects power.

Freedom of action, for instance, means that the full might of the U.S. joint force can be brought to bear to ensure that U.S. allies are not coerced by China. As long as the United States maintains dominance in overall balance of military forces (discussed in the next subsection), U.S. freedom of action entails the ability to preserve the status quo. For the United States, the ability ensure freedom of access requires an RUK capable of surviving in a hostile staging area. Thus, survivability factors, such as mobility and stealth, are critical for weapons systems.

Since China is able to compensate for its inability to create maritime depth by exploiting continental depth, it can make a distinction between the battlespace and staging area. The ability to make this distinction is a major advantage because it opens the door to a force posture that focuses more heavily on stand-off than on direct engagement. Thus, the Chinese RUK is dominated by land-based cruise and ballistic missiles.

Decades of deliberating pursuing an asymmetric strategy have left an indelible mark on the Chinese RUK. China's cruise and ballistic missile programs have been described as a "pocket of excellence" within its generally distressed and ineffectual defense-industrial-technological base.[34] The missile sector of the Chinese defense industry has made steady

[34] Evan S. Medeiros, et. al., *A New Direction for China's Defense Industry* (Santa Monica, CA: RAND Corporation, 2005),. 51.

technological advances for the last 50 years—a stark contrast to the inability of China to indigenously develop and produce modern naval and aviation platforms.[35] As China grows more willing and able to confront the U.S. military presence in East Asia, it relies on anti-ship cruise missiles (ASCMs) and anti-ship ballistic missiles (ASBMs) to threaten a maritime zone of exclusion within its first island chain and to plausibly threaten all maritime assets west of Guam. Advances in propulsion technology have made land-attack cruise missiles LACMs an important supplement to theater ballistic missiles.

[35] Medeiros, 2005, p. 52.

Table 4. Primary Theater Strike Missiles in Chinese RUK[36]

Designator	Type	Range (miles)	Guidance	CEP (feet)	Payload (kg)	# in Service	Comments
HY-2 (CSS-N-3 SILKWORM)	ASCM	59	autopilot w/ active radar or IR; self-control plus homing				
HY-3 (CSS-X-6 SAWHORSE)	ASCM	112	INS & active radar				
HY-4 (CSSC-7 SADSACK)	ASCM	90	autopilot & active radar				
YJ-2 (CSSC-X-8 SACCADE)	ASCM	75	INS, active radar				
SS-N-22 (land-based variant)	ASCM	110	INS, datalink, active & passive radar				
SS-N-27 (land-based variant)	ASCM	137	INS, active radar				
HN-1	LACM	373	INS/GPS, TERCOM	50-65	400		
HN-2A	LACM	1118	INS/GPS, TERCOM	16	400		
DF-11 (CSS-7)	SRBM	174-217	strap-down INS, computer digitized with terminal control	1640	800	435-475	single or cluster warhead; 30-45 min. launch prep
DF-11A (CSS-7 Mod 2)	SRBM	217-329	INS & GPS	< 656	500	?	likely CEP of 65-100 ft with option for optical correlation terminal targeting
DF-15 (CSS-6)	SRBM	373	strap-down INS, computer digitized with terminal control	1968	600	275-315	single or cluster warhead; 30 min. launch prep; enhanced accuracy with GPS
DF-21 (CSS-5)	MRBM	1335	gyro-platform INS with onboard computer	984-1312	600	19-23	10-15 min. launch prep; longer range Mod 2 to replace Mod 1
DF-21A (CSS-5 Mod 2)	MRBM	1553	INS with radar correlation and GPS	164	500		possible option for EMP warhead

[36] Sources on next page.

Table 4 shows combat characteristics of the major land-based theater strike missiles in China's inventory.[37] These missile are the foundation of China's anti-access capability.

The relationship between anti-access and reconnaissance-strike is a source of possible confusion. Anti-access strategies and capabilities attempt to create a zone of exclusion in which the risk of operating is prohibitively high for an adversary. China's stockpile of land-based theater missiles is able to achieve anti-access effects when potential downrange weapons density is high enough to create a risk of destruction seen as prohibitive by U.S. commanders.

Surface ships are generally more vulnerable than aircraft, which are generally more vulnerable than submarines. Theoretically, a highly robust network of sensors and shooters could create a zone of complete anti-access. In reality, China's undersea warfare capabilities practically guarantee a high degree of assured access for U.S. submarines. Furthermore, China's anti-access network will always be more vigorous closer to the mainland, as a greater number of cruise and ballistic missiles can be employed at this range.

The process by which China's arsenal of cruise and ballistic missiles create the operational effect of anti-access is governed by two specific attributes of the arsenal. Land-based cruise and ballistic missiles constitute the technological foundation for anti-access. Both are stand-off weapons that allow China to form an asymmetric strategy based on principles of range and density.

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[37] Guidance system descriptions come mostly from the Nuclear Threat Initiative's China Database, supplemented by information from the Claremont Institute's MissileThreat.com project. Chinese Defence Today's webpage on "Missiles and Space Launch Vehicles" provided supplemental figures for CEP and stockpile size. NTI provided details regarding ballistic missile launch preparation. Quantitative data obtained from this source was usually inaccurate. When possible, NTI numbers are not used unless double-checking proves them congruent with third-party estimations. Range, number of missiles in service, CEP, and payload may occasionally represent a discretionary average of reported measurements from two or more sources.

- Range is the "extent or distance limiting the operation or action of something."[38] Stand-off weapons allow China to engage the United States indirectly, possibly nullifying its conventional air and naval inferiority.
- Density potential downrange is a measure of the total ordnance mass with which China can threaten a battle area. When concentrated in significant numbers, cruise and ballistic missiles have the potential to credibly threaten U.S. surface ships and regional bases, denying the United States entry into certain contested zones or, in the extreme, access to an entire region.

Table 5. Range and Density as Determinants of Anti-Access Strength

	Short Range	**Long Range**
Low Density	*Surface fleet:* may be unsafe in littoral waters	*Surface fleet:* some danger to entire fleet
	Regional bases: only in marginal danger	*Regional bases:* only in marginal danger
High Density	*Surface fleet:* definitely unsafe in littoral waters	*Surface fleet:* very inhospitable theater environment for surface fleet
	Regional bases: all but a few safe	*Regional bases:* may be in significant danger

Table 5. shows the threat to the U.S. surface fleet and regional bases from variable binary range and density inputs. Range and density work together to determine the strength of the anti-access effect, and thus the RUK. Simply, potential weapons density determines the impenetrability of

[38] Joint Chiefs of Staff, *Joint Publication 1-02: Department of Defense Dictionary of Military and Assorted Terms* (as amended through Oct. 31, 2009), p. 449.

the anti-access zone, and the distribution of missile ranges in the stockpile determines the size of the anti-access zone.

C. First Order Cause: The Balance of Conventional Forces

The United States attempts to control the Western Pacific by creating maritime depth via its network of regional basing facilities and a strong blue water naval presence. China, on the other hand, lags behind the United States in the quantity, quality, and training of their air and naval forces.[39]

A rough depiction of comparative fleet strengths is shown in Table 6. Any attempt by the Chinese to engage the United States in competition for symmetric control of the Western Pacific would be costly and unsuccessful. Because China sees an ability to challenge hostile powers in the Western Pacific as vital to its national security, it is forced into an asymmetric strategy for projecting power into the theater.

Table 6. U.S. and Chinese Fleet Strength (Large Strike Craft)[40]

	United States		China	
	Current	*Number Projected*	*Current*	*Number Projected*
Cruise Missile Submarines				
Converted Ohio SSGNs	4	0	—	—
Aircraft Carriers				
CVN Multipurpose	10	2	0	0
Non-nuclear Multipurpose	1	0	0	1
Cruisers				
Guided Missile Cruisers	22	0	0	0
Destroyers				
DDG-1000s	0	7	—	—

[39] Medeiros, 2005, ch. 3-4.
[40] Not all U.S. assets may be available for East Asian theater operations. Concept of operation for U.S. frigates is primarily anti-submarine warfare. Table excludes smaller ships (e.g. Fast Attack Craft). Source: Stephen Saunders, ed., *Jane's Fighting Ships 2007-2008* (Cambridge, UK: Cambridge University Press, 2007), pp. 115, 873.

Other DDGs	52	10	27	2
Frigates				
Littoral Combat Ships	0	4	—	—
Other Frigates	30	0	47	4

Table 7 shows the program of record for the U.S. RUK; China's program of record for its RUK is unknown, but a close approximation of its current RUK is reflected in the list of land-based cruise and ballistic missiles in Table 4 and the S-300s in Table 10.

These data illustrate the most fundamental difference between the hardware profile of U.S. and Chinese RUKs. The U.S. RUK is platform-intensive. In fact, each factor discussed in this section incentives a platform-intensive RUK. The scarcity of dry land encourages the creation of a large surface fleet dominated by aircraft carriers. The fact that the U.S. staging area doubles as the contested battlespace encourages the development of mobile, stealthy (i.e., survivable) reconnaissance-strike platforms.

Table 7. U.S. Reconnaissance-Strike Platforms through 2015

	Tactical Aircraft	C4ISR	Other
Air Force Programs	10 – 11 theater strike wing-equivalents (with 72 primary mission aircraft per wing-equivalent)	8 ISR wing-equivalents (with up to 380 primary mission aircraft)	5 long-range strike (bomber) wings (with up to 96 primary mission aircraft)
	6 air superiority wing-equivalents (with 72 primary mission aircraft per wing-equivalent)	3 command and control wings and 5 fully operational air and space operations centers (with a total of 27 primary mission aircraft)	
		10 space and cyberspace wings	
Navy Programs	10 – 11 aircraft carriers and 10 carrier air wings	126 – 171 land-based ISR and electronic warfare (EW) aircraft (manned and unmanned)	4 guided missile submarines

Finally, because the United States leads in the overall-balance of conventional forces, it is able to exploit the global commons and develop an RUK based on mobile platforms.

The Chinese response is an RUK that attempts to control the Western Pacific with stand-off reconnaissance-strike from the continental periphery. Vis-à-vis the United States, China's maritime strategy is "essentially a sea-denial strategy."[41]

This section's argument is summarized in Table 8.

Table 8. Summary of First-Order Factors Shaping U.S. and Chinese RUKs

	Theater Geography	Threshold for Military Victory	Balance of Forces
Status of Factor	China = continental power; U.S. = maritime power	Does the U.S. have freedom of action in W. Pac?	U.S. has conventional force superiority across all domains (air, sea, undersea)
Durability of Factor	Permanent	Long-term (30+ years)	Medium-long-term (15+ years)
Influence of Factor on U.S. military	Dry land scarce; U.S. often forced to operate from long distances	W. Pac is both a potential battlespace and a staging area	U.S. Able to exploit the commons in the air and at sea
Hardware Implications for U.S. RUK	+ Long-range systems; + Maritime systems	+ Survivability (stealth, mobility, etc.)	+ Mobile platforms
Influence of Factor on Chinese military	Enormous potential for land-based dispersal	Only need to limit access to W. Pac as an effective staging area for operations inside first island chain	Will lose vast majority of symmetric platform-on-platform engagements in global commons (i.e., tacair dogfights, ASW, etc.)
Hardware Implications for Chinese RUK	+ Land-based systems	+ Anti-access systems	+ Stand-off strike systems

Asymmetry can be defined as "acting, organizing, and thinking differently than opponents in order to maximize one's own advantages, exploit an opponent's weaknesses, attain the initiative,

[41] Paul Dodge, "China's Naval Strategy and Nuclear Weapons: The Risks of Intentional and Inadvertent Nuclear Escalation," *Comparative Strategy* 24, No. 5 (Nov.-Dec. 2005), p. 416.

or gain greater freedom of action."[42] China's asymmetric RUK responds to three factors: theater geography, the threshold for military victory, and the conventional force balance.

[42] Steven Metz and Douglas V. Johnson, *Asymmetry and U.S. Military Strategy: Definition, Background, and Strategic Concepts* (Carlisle, PA: Strategic Studies Institute, U.S. Army War College, 2001), p. 9.

III. Operations

This section identifies the factors that will determine the long-term direction of the reconnaissance-strike competition. It accomplishes this by:

- Specifying which reconnaissance-strike skills are critical to the United States and China;
- Assessing which skill is most fundamental to the reconnaissance-strike mission of each military, and whether elements of that skill are generalizeable; and
- Identifying key variables that determine the efficacy with which each side is able to execute its primary reconnaissance-strike skill.

Although this section's analysis may partly illuminate the current state of the competition, that is not its purpose. Its intent is to enable generalizations on military investment in Section IV.

A. Assessing Critical Skills

In the Pacific theater, there are two primary skills that the U.S. RUK must be able to accomplish: suppression of enemy air defenses (SEAD) and the destruction of mobile missile launchers. Table 9 provides a snapshot of these skills, along with three critical Chinese reconnaissance-strike skills. The two U.S. skills are quite similar: both require finding and tracking mobile targets that are behind enemy lines—often deep behind enemy lines.

Of the two, the former is more important. Since World War I, the United States has never won a major campaign without first establishing air superiority. If able to successfully execute SEAD, the United States will be able to penetrate Chinese airspace with less survivable assets, maximizing downrange weapons density and hastening destruction of China's mobile missile launchers.

Table 9. Key U.S. and Chinese Reconnaissance-Strike Skills

	U.S. Strike Tasks		Chinese Strike Tasks		
	Suppression of Enemy Air Defenses	Destroying Mobile Missiles	Land-Based Maritime Control	Strikes on FOBs	Air Defense
Reconnaissance-Strike?	Yes	Yes	Yes	Yes	No, but RUK-like system
Anti-Access Strike?	No	No	Yes	Not directly	Yes
Current Hardware Approach	Platform-intensive	Platform-intensive	Projectile-intensive	Projectile-intensive	Projectile-intensive
Short-Term Potential for Diversifying Hardware Approach	Low	Low	None	None	Low-Medium

There are three critical skills for Chinese RUK: land-based maritime control, strikes against U.S. FOBs, and air defense. The first two are clearly reconnaissance-strike skills, while the third—as discussed in Section I—is functionally different but has the same long-term operational effect.

The first and third are clearly anti-access skills, while the second arguably is not anti-access because its goal is to stymie forces before they are actually projected into the battlespace. In other words, U.S. FOBs are effectively U.S. staging areas. Just as U.S. attacks on Chinese mobile missile launchers cannot really be considered anti-access, neither can Chinese attacks on U.S. FOBs. Thus, only land-based maritime control is both a clear anti-access skill and a reconnaissance-strike skill.

Moreover, land-based maritime control is the only anti-access skill that allows China to confront the heart of the U.S. platform-intensive RUK: aircraft carriers. Aircraft carriers are the unquestionable capital platform in the U.S. RUK. Aircraft carriers are mobile, maritime platforms with unlimited range, excellent defenses, and a concept of operations that exploits U.S. conventional superiority in every nearly all domains (air, sea, and undersea). Thus, the tactical competition between Chinese land-based anti-ship missiles and U.S. aircraft carriers is arguably the central interaction of the two RUKs.

The remainder of this section analyzes the ability of the Chinese RUK to hunt U.S. aircraft carriers and the ability of the U.S. RUK to suppression Chinese air defenses.

B. Hunting U.S. Aircraft Carriers

The ability to penetrate deep into enemy territory and apply a high weapons density belongs almost exclusively to airpower. In the Western Pacific—with a strategic environment shaped by advanced RUKs—carrier-based airpower offers two significant advantages over land-based airpower. First, carrier-based aircraft are always mobile, even when on the runway. Because mobile targets are harder to find and destroy than fixed targets, this confers a survivability advantage. Second, aircraft carriers can manipulate sortie rate by changing distance to target, depending on the threat environment. This flexibility increases both lethality and survivability.

The current threat to U.S. carrier-based airpower from Chinese mobile missile launchers has a historical antecedent. After the Vietnam War, U.S. aircraft carriers appeared to face a major threat from Soviet Tu-22M Backfire bombers, armed with supersonic Kh-22M Kitchen ASCMs.[43] The carrier battle group's primary means of defense was the carrier-based F-14. The short-range F-14 could not easily defend the carrier against a long-range bomber armed with super-sonic cruise missiles. Thus, planning for the outer-air battle involved flying E-2Cs and F-

[43] Thomas P. Ehrhard and Robert Work, Electronic Briefing, Center for Strategic and Budgetary Assessments, "The Unmanned Combat Air System Carrier Demonstration Program: A New Dawn For Naval Aviation?" July 11, 2007, accessed online: [www.csbaonline.org/4Publications/PubLibrary/S.20070711.The_Unmanned_Comba/S.20070711.The_Unmanned_Comba.pdf].

14s far enough in front of the carrier to intercept the Tu-22s before they could launch their ASCMs.[44]

One U.S. intelligence official was quoted saying that the Backfire was "a vital part of [Soviet] strategic defense forces to keep Western carrier battle groups from striking important targets within the Soviet land-mass."[45] The calculation was simple: if land-based anti-carrier weapons (land-based bombers, in this case) can strike U.S. carriers at greater range than the carriers can strike land-based targets, aircraft carriers are placed at high risk and their value diminishes greatly.

Roughly the same dynamics are at play with today's carrier-based aviation, only to a greater degree. One of the most troubling developments in recent years has been the application of ballistic missiles to anti-ship missions. The Pentagon's 2008 report to Congress on Chinese military power says the following about ASBMs: "One area of investment involves combining conventionally-armed ASBMs based on the CSS-5 (DF-21) airframe, [ISR] for geo-location and tracking of targets, and onboard guidance systems for terminal homing to strike surface ships on the high seas or their onshore support infrastructure. This capability would have particular significance, as it would provide China with preemptive and coercive options in a regional crisis."[46]

The 1,500 mile range of the DF-21 easily outstrips the combat radius of the any F-18 or F-35 variant. Successful development and production of ASBMs could force U.S. carriers to operate far enough from China that their contribution of combat power would be close to negligible.

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[44] Barry Watts, personal email to author, Dec. 8, 2009.
[45] Quoted in Ehrhard and Work, Electronic Briefing, 2007.
[46] Office of the Secretary of Defense, *Military Power of the People's Republic of China* (Washington, D.C.: Department of Defense, 2008), p. 23.

China's ability to execute an anti-carrier strategy, however, relies on the ability to locate and track U.S. carriers. This paper divides ISR platforms into three tiers based on achievable surveillance footprints.

Satellites in low-earth orbit trajectories comprise the first-tier of ISR platforms. These are the most expensive ISR platforms and the most difficult to destroy.[47] Satellite surveillance is simply the most practical way to detect surface ships. The South China Sea, which comprises less than five percent of the Western Pacific, is itself over a million square miles. China's primary challenge in constructing reconnaissance satellites has traditionally been producing sophisticated sensors. For years, Chinese military satellites lacked the capability to reliably locate U.S. aircraft carriers.[48]

The situation in 2010 is much different. First, although inconclusive, there is evidence that China has fielded, ahead of schedule, a strategic cueing network for the DF-21A that relies on dual-use satellites.[49] Moreover, China is expected to field a synthetic aperture radar (SAR) satellite by 2012. SAR satellites are useful for tracking aircraft carriers because they can deduce speed and direction from ship wakes that are imaged with microwave transmission.[50] Finally, since carriers have a large electromagnetic signature that can be readily picked up by electronic intelligence (ELINT) satellites. China had an active ELINT program through the late 1980s, and may be resurrecting the program.[51]

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[47] Carlo Kopp, "Hard-Kill Counter ISR Programs," expanded and updated from *Defense Today* (Nov./Dec. 2006), accessed online: [http://www.ausairpower.net/APA-Counter-ISR-Programs.html].
[48] Loren Thompson, "Aircraft Carrier (In)vulnerability: What it Takes to Successfully Attack an American Aircraft Carrier," Lexington Institute Naval Strike Forum (Aug. 2001), accessed online: [http://www.lexingtoninstitute.org/library/resources/documents/Defense/aircraft-carrier-invulnerability.pdf], slide 9.
[49] Mark Stokes, "China's Evolving Conventional Strike Capability," Project 2049 Institute, Sept. 14, 2009, p. 16.
[50] Stokes, 2009, p. 16.
[51] Stokes, 2009, p. 17.

Second tier systems are comprised of high-flying unmanned aerial vehicles and large ISR platforms, such as JSTARS.[52] This paper also includes advanced ground-based radar in this tier. Even if China were able to locate carriers with first tier platforms, it would need second tier platforms to track the carriers, which can cruise at 25 knots for weeks at a time.[53] Here, too, China encounters problems. Over-the-horizon radars, such as those found on Tarawa, are not powerful enough to get a precise fix on even large surface ships after initial identification.[54] Paul Dodge summarizes the problem with second tier ISR systems: "those systems that can track carriers use such a narrow search band that it is highly impractical to use them to search a wide area. To make matters worse for the PRC, those assets that it does possess that could aid in the detection and tracking of carriers would be destroyed within the opening hours of a conflict."[55]

Third tier systems include fixed wing aircraft modified for ISR missions. Until very recently, Chinese battlefield reconnaissance was almost exclusively the domain of these aircraft.[56] These platforms have small surveillance footprints and are highly vulnerable to interception.

Two factors seem dispositive of the near-term risk to U.S. aircraft carriers. The first factor is the success of the Chinese in fielding a reliable space-based detection capability. Unfortunately for the Chinese, second and third tier sensor systems face the same survivability concerns as standard surface ships and tactical aircraft.

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[52] Kopp, 2006.
[53] Dodge, 2005, p. 423.
[54] Dodge, 2005, p. 423.
[55] Dodge, 2005, p. 423.
[56] Martin Andrew, "New Advances in PLA Battlefield Aerospace and ISR," *China Brief* 9, No. 2 (Jan. 22, 2009), accessed online: [www.jamestown.org/programs/chinabrief/single/?tx_ttnews[tt_news]=34390&tx_ttnews[backPid]=25&cHash=feb05a7d6a].

The second factor is the technical performance of the DF-21A ASBM. If China's anti-fleet capability were to stay the domain of cruise missiles, their probability of success in executing anti-carrier missions would appear bleak.

There are two reasons this is so. First, notwithstanding the purported range of the HN-2A, cruise missiles have limited stand-off capability relative to ballistic missiles. The HN-2A, though, is an LACM. No ASCM has enough range to credible threaten carrier-based air operations.

Second, because of their slow speed, cruise missiles, which spend more time than ballistic missiles within the line-of-sight of jammers deployed near a target, are more vulnerable to GPS jamming than ballistic missiles. Time spent in jammers' line-of-sight gives inertial navigation systems more time to drift.[57] Owen Cote writes that this imposes requirements for a terminal sensors, which requires either "more substantial pre-launch mission planning, a data link that allows man-in-the-loop guidance, or reliable automatic target recognition" techniques.[58]

C. Suppressing Chinese Air Defenses

China's IADS would form the basis of its anti-air effort in a future conflict with the United States.

The oldest Chinese SAM is the CSA-1 (Chinese designations: HQ-2, HQ-2A, and HQ-2B), modeled after the Russian SA-2 Guideline.[59] Table 10 shows that the CSA-1 class still

[57] Owen Cote, Jr., "Precision Strike From the Sea: New Missions for a New Navy," A Report of the M.I.T. Security Studies Program's Second Annual Levering Smith Conference, 1997, accessed online: [http://web.mit.edu/ssp/Publications/confseries/strike/strike_report.html].
[58] Cote, 1997.
[59] "HongQi 2 Surface-to-Air Missile System," Feb. 20, 2009, accessed online: [http://www.sinodefence.com/army/surfacetoairmissile/hongqi2.asp].

constitutes the preponderance of China's air-defense capability.[60] One battery of CSA-1s consists of 12 missiles and launchers with target sensors at a central control station.[61] Shooters, sensors and targeting (S&T), and communications hardware form the integrated network that constitutes an IADS.

CSA-1 batteries are known to be deployed at six or more airfields stretching from Fuzhou down to Zhangzhou, near Xiamen, and also at a base near Liancheng.[62] These sites are clustered around the coastline opposite Taiwan. The CSA-1 has a range of nearly 40 miles, not quite long enough to be effective against aircraft operating over Taiwan.[63]

Table 10. Major Chinese Integrated Air Defense Systems

Designator	# of Launchers in Service	Primary Basing	Range	Coverage
SA-20 (S-300PMU2)	32	Land	121 miles	Area Defense
SA-20 (S-300PMU1)	64	Land	93 miles	Area Defense
SA-10B (S-300PMU)	32	Land	93 miles	Area Defense
HQ-9	64	Land/Ship	Long	Area Defense
KS-1A	60	Land	Medium	Area Defense
HQ-6 (HQ-61)	30	Land/Ship	Short	Point Defense
CSA-1 and variants	400	Land	37 miles	Area Defense

The most advanced air defense assets are the S-300 (NATO: SA-10 Grumble) class. Designed by Russia in the 1990s, the S-300 is a highly effective area air defense system, comparable to the U.S. Patriot Missile Air Defense System.[64] Three models exist: the PMU,

[60] List of systems and number of missile launchers in service taken from Pentagon China Report, 2008. Data on range, coverage, and basing collected from SinoDefence.com: [www.sinodefence.com/weapons/missile/surface-to-air.asp]; range of CSA-1 from: [www.missilethreat.com/missiledefensesystems].
[61] Bill Gertz and Rowan Scarborough, "Missile Deployment," *Inside the Ring* (Oct. 18, 2002), accessed online: [www.gertzfile.com/gertzfile/ring101802.html].
[62] Gertz, 2002.
[63] "U.S. DOD Reports China's Growing Missile Power," *Jane's Missiles and Rockets* August 1, 2000; cited in "Hongqi-2 (HQ-2)," accessed online: [www.missilethreat.com/missiledefensesystems/id.26/system_detail.asp].
[64] "S-300PMU (SA-10) Air Defense Missile System," May 5, 2008, accessed online: [http://www.sinodefence.com/army/surfacetoairmissile/s300.asp]

PMU1, and PMU2. The S-300's resistance to jamming and the fact that it has two to three times the range of the CSA-1—allowing it to strike aircraft over Taiwan—make it a formidable system.[65] According to the Air Force's general in charge of U.S. forces in Japan, new Chinese air defenses would make it "difficult, if not impossible" for F-15s and F-16s to penetrate Chinese air space.[66] Only F-22s and B-2s could confidently evade the S-300.[67] Like virtually all Chinese SAMs, TEL garrisons give the system mobility, increasing the ISR burden on the United States.

Table 11. Elements of an S-300 Integrated Air Defense Regiment

	PMU	PMU1	PMU2	Function
Truck-towed TEL based on KrAZ-260, each carrying four missile transport-launch containers (TLC)	32	-	-	Shooters
Self-propelled 8X8 TEL based on MAZ-543, each carrying four TLCs	-	16	16	Shooters
Phased-array illumination and guidance radar	8	8	8	S&T
Low-altitude early warning radar	8	8	8	S&T
Detection and target designation radar	8	8	8	S&T
Command post including 54K6E(2) combat control system and 64N6E(2) early warning radar	1	1	1	↓
54K6E(2) Combat control system	1	1	1	Comm.
64N6E(2) Early warning radar and IFF (identification, friend or foe) interceptor	1	1	1	S&T

Table 11 shows the composition of an S-300 regiment for each subtype.[68] The 54K62(2) mobile command post is the most important component on the table. The 54K62(2) is responsible for networking all battery components and integrating the battery engagement radars.[69] Essentially, the mobile command post is what makes the IADS regiment integrated.

[65] Testimony of Richard D. Fisher, Jr., for March 16, 2006, *United-States China Economic and Security Review Commission* hearing, p. 11, quoted in Ronald O'Rourke, CRS Report for Congress on "China Naval Modernization: Implications, For U.S. Navy Capabilities—Background and Issues for Congress," updated June 15, 2007, p. 76.
[66] Lt. Gen. Bruce Wright, quoted in Associated Press, "China's Military Nearly Impenetrable," Sept. 29, 2007, accessed online: [www.military.com/NewsContent/0,13319,150877,00.html].
[67] Fisher, 2006, quoted in O'Rourke, 2007, p. 76.
[68] Adapted from "S-300 PMU (SA-10) Air Defense Missile System," 2008.
[69] "Warsaw Pact/Russian Air Defense Command Posts," Air Power Australia, Dec. 12, 2008, accessed online: [www.ausairpower.net/APA-Rus-ADCP-CP.html].

For SEAD, large numbers of air assets are needed. Because cruise and ballistic missiles are mobile, aircraft will be much more effective taking them out if the aircraft have the ability to loiter over the battlefield. Better yet is the ability to have a wing of aircraft continuously loiter over the battlefield. Once cued by sensors, these loitering aircraft could quickly strike fleeting targets.[70] To make this picture a reality, a much larger fighter force is needed. Assuming they were based 1,700 miles from the conflict area and were supported by the right number of tankers, a wing of 72 Raptors could keep only six aircraft in the air and near the battlefield on a sustained basis.[71]

Two other challenges exist for SEAD. First, in-theater basing may not be adequate for sustained, high-intensity air campaigns. As discussed in Section II, the United States has limited options for basing facilities to accommodate U.S. tactical aircraft.[72] Further, Asian basing in general is lacking. Excluding the Middle East, the United States has fought three major conflicts in Asia since World War II: Korea, Vietnam, and Afghanistan. In all three of these conflicts, ex ante basing infrastructure was inadequate for sustained, large-scale tactical air operations.[73]

Second, special challenges may exist for targeting enemy cruise missile launchers. Currently, U.S. joint doctrine views counterforce as the preferred method for countering theater cruise and ballistic missiles. Unfortunately, even with guided weapons and significant advances in surveillance technology, improvements in targeting have been largely limited to fixed targets.[74] Ground-launched missiles are especially difficult to target, as the proliferation of smaller launch vehicles increases the difficulty of identifying missile launchers within the

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[70] For more information on the mobile target kill chain, see Christopher J. Bowie, Robert P. Haffa, and Robert E. Mullins, *Future War: What Trends in America's Post-Cold War Military Conflicts Tell Us About Early 21st Century Warfare* (Rosslyn, VA: Northrop Grumman Analysis Center, 2003), pp. 4-5.
[71] Bowie, et. al., 2003, p. 59.
[72] Krepinevich, Watts, and Work, 2003, p. 3.
[73] Bowie, 2002, p. 29.
[74] Gormley, 2001, p. 64.

general population of military and civilian vehicles.[75] One analyst writes that their "relatively compact size suggests more flexible launch options, or mobility for ground-launched versions and a smaller logistics burden—making them even less susceptive to counterforce targeting than Iraqi *Scuds* were during *Operation Desert Storm*."[76] The same author, in a different source, complains that the number of civilian and military vehicles visually similar to mobile missile launchers will more than double as smaller cruise missile launchers are fielded. "As this 'look-alike', or 'confuser' population grows, airborne surveillance sensors will be hard pressed to distinguish real targets from false ones."[77]

Briefly setting aside ISR uncertainties, the concept of operations for SEAD is relatively simple. SEAD focuses heavily on utilization of short- and medium-range theater weapons in the air and on the surface. SEAD assets can be divided into two distinct categories, access-sensitive platforms and access-insensitive platforms. Here, access sensitive describes platforms with poor survivability prospects in hostile environments. Most surface ships and non-stealthy aircraft fall in this category. Access-insensitive describes "kick in the door" platforms capable of thriving in hostile environments.

Enough is already known about the extant class of Chinese air defenses (this class excludes the S-400 PMU3 prototypes, the S-500 concept, and—perhaps wrongly—the S-300V, or HQ-18) to construct a simple attrition model for SEAD over the Chinese mainland. The purpose of the attrition model is *not* to generate an accurate prediction of the operation's result or

[75] National Air Intelligence Center, *Ballistic and Cruise Missile Threat* (Wright-Patterson Air Force Base, OH: U.S. Air Force, 2000), p. 23.
[76] Dennis M. Gormley, "Hedging Against the Cruise Missile Threat," *Survival* 40, no. 1 (Spring 1998), pp. 95-96.
[77] Gormley, 2001, p. 65.

timeframe, but to demonstrate the importance to mission success of the primary uncertainty: probability of finding air defenses [p(find)].

The best open-source estimates give China 128 S-300-class surface-to-air missile launchers: 32 PMU launchers, 64 PMU 1s, and 32 PMU2s. Table 10 presents a rundown of all Chinese air defenses.

The model runs on the following initial assumptions:

- Only the F-22 and B-2 are survivable against China's advanced integrated air defenses (S-300-class).
- B-2s can only conduct operations out of Diego Garcia and Whiteman AFB (MO). Through T+3, they are not engaged in SEAD, but rather tasked with counterforce missions against theater cruise and ballistic missile or against Chinese forces massed for a cross-Strait movement. This assumption is made to simplify the SEAD concept of operations. Additionally, it tests how well the United States can cope in an especially hard scenario. Thus, SSGNs are not employed (although they are addressed later in this section).
- For the purposes of this model, the United States has 7 squadrons of F-22 Raptors. Each squadron consists of 24 aircraft in the primary aircraft inventory (PAI), plus two in back-up aircraft inventory (BAI). Only the PAI will fly combat sorties.
- Every F-22 based in the first island chain (Kadena) is destroyed in China's first strike. Every F-22 based on Guam and eastward survives. To keep the model simple, F-22s that survive first-strike are 100% survivable through T+3.[78]
- Table 8's sortie rate is estimated based on distance to target and aircraft speed. To conserve fuel, combat-rigged F-22s will fly at roughly Mach 1.3 (just under 1,000 mph). Unrefueled combat radius is just over 600 miles. Given these statistics, only Kadena is ideal for high-intensity operations (1 or more sorties per day).[79] Andersen (GU), Elmendorf (AK), and Hickman (HI) can be used for low-intensity operations (in that order of preference).

[78] An Air Force combat simulation concluded that the F-22 enjoys a 108:0 kill ratio against Sukhoi Su-27s and Su-30 Flankers. See Amy Butler and Douglas Barrie, "Italy Wins JSF Final Assembly; UK Presses Maintenance, Support," *Aviation Week*, June 19, 2006, accessed online: [www.aviationweek.com/aw/generic/story_generic.jsp?channel= aerospacedaily&id=news/JSFM06196.xml].
[79] Definition of intense combat found in 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 Corporation, 1999).

Table 12. Notional F-22 Squadron Availability and Sortie Generation

	Kadena (JP)	Andersen (GU)	Hickam (HI)	Elmendorf (AK)	Langley (VA)	
Est. sortie rate/day across all Ts for SEAD	*1.1*	*0.8*	*0.65*	*0.75*	*N/A*	*Total sorties/day (24 PAI/Squad)*
Squadrons at T+0	1	1	1	2	2	*97.2*
Squadrons at T+1	0 (1 killed)	2	0 (1 to GU)	2	1 (1 in transit to GU)	*74.4*
Squadrons at T+2	0	3	0	2	1	*93.6*
Squadrons at T+3	2	1 (2 to GU)	0	2	1	*108*

Table 13. F-22 Combat Effectiveness Across Time with Low P(Detect)

	Optimization	Air-Ground Armament	Aimpoints/Sortie	P(Detect)	P(Detect & Kill - 2 shots)	Kills/Sortie
T+1	50-50: Air-Air, Air-Ground	GBU-32 JDAM (2)	1	0.2	0.18	0.18
T+2	Air-Ground	GBU-39/B (8)	4	0.3	0.28	1.10
T+3	Air-Ground	GBU-39/B (8)	4	0.5	0.46	1.83

Table 14. F-22 Combat Effectiveness Across Time with High P(Detect)

	Optimization	Air-Ground Armament	Aimpoints/Sortie	P(Detect)	P(Detect & Kill - 2 shots)	Kills/Sortie
T+1	50-50: Air-Air, Air-Ground	GBU-32 JDAM (2)	1	0.4	0.37	0.37
T+2	Air-Ground	GBU-39/B (8)	4	0.5	0.46	1.83
T+3	Air-Ground	GBU-39/B (8)	4	0.7	0.64	2.57

Table 12 shows expected output of F-22 sorties. Because a carrier-based air-to-air campaign would likely take place contemporaneous to T+1, F-22 sorties during this time will carry a standard combat load of two AIM-120Cs and two AIM-9 air-to-air missiles. For air-to-ground strikes, T+1 F-22s will carry two 1,000 pound-class Joint Direct Attack Munitions (JDAMs). It would be unrealistic to customize F-22s for SEAD until air-to-air threats have been greatly reduced.

However, for T+2 and T+3, Chinese fighters will have been significantly attrited and F-22s can fly sorties with a customized air-ground strike load consisting of eight GBU-39/B Small Diameter Bombs.[80] Table 12 shows the initial F-22 squadron beddown and squadron movement as the SEAD campaign progresses though through T+3. Additionally, it shows the average estimated sortie generation across each time span.

Table 15. SEAD Targets Across Time

	T+1	**T+2**	**T+3**
PMU	32	0	0
PMU1	64	0	0
PMU2	32	0	0
HQ-9	0	64	0
KS-1A	0	60	0
HQ-6	0	0	30
CSA-1	0	0	400
TOTAL	**128**	**124**	**430**

Single-shot kill probability (not represented on table) is calculated by assuming probability of hit at 0.75 and probability of kill at 0.95 for all GBUs. In both F-22 optimizations, 2 GBUs are allocated to each aimpoint. Thus, the double-shot kill probability is roughly 0.92. Increased probability of detection throughout the conflict's duration represents the cost to the F-22 of avoiding attrition. The more hostile the tactical environment, the less freedom the pilot has

[80] Details of both configurations found at "F-22 Raptor Weapons," Jan. 21, 2008, accessed online: [http://www.globalsecurity.org/military/systems/aircraft/f-22-weapons.htm].

to loiter over the airspace and conduct ISR. As the tactical environment becomes more hospitable, probability of detection is increased.

Tables 13 and 14 show two different scenarios for SEAD based on the values assigned to p(detect). The key numbers from these tables are Kills/Sortie for each T. Combined with the sortie rate derived in Table 12, Kills/Sortie allows for an estimation of Kills/Day. Table 15 shows SEAD targets for each T.

Dividing the appropriate column total from Table 15 by respective Kills/Day figure from Table 13—the pessimistic scenario—yields the predictions that all T+1 targets can be destroyed in 229 hours, T+2 targets in 114 hours, and T+3 targets in 208 hours. Thus, under this version of the model, the United States can be expected to suppress Chinese air defenses after 23 days..

Dividing the appropriate column total from Table 15 by respective Kills/Day figure from Table 14—the optimistic scenario—yields the predictions that all T+1 targets can be destroyed in 112 hours, T+2 targets in 69 hours, and T+3 targets in 149 hours. Thus, under this version of the model, the United States can be expected to suppress Chinese air defenses after nearly 14 days.

This particular model endeavored to make as few assumptions as possible, limiting the analysis to operations against well-defined target set by one strike platform. With only a 20 percent improvement in p(detect) from Table 13 to Table 14, the campaign was 67 percent more efficient, as measured by campaign length. The implication of this analysis is that even small improvements or deteriorations in detection proficiency can have outsized effects on the SEAD campaign.

IV. Investment

The purpose of this paper is to assesses how the interaction of asymmetric reconnaissance-strike complexes shape incentives for future investment in the U.S. and Chinese reconnaissance-strike complexes. Three questions are embedded in this research puzzle:

1. What are the major sources of asymmetries between U.S. and Chinese RUKs?
2. How do these asymmetries influence the hardware configuration of each RUK?
3. What are the key factors that influence the interaction of asymmetric RUKs?

Section II answered the first and second question. Theater geography, the threshold for military victory, and the overall balance of conventional forces are the ultimate causes of U.S.-Chinese asymmetry in reconnaissance-strike.

These factors lead the United States to develop an RUK based around high-quality (highly survivable) mobile platforms. Long-range and sea-based systems are especially valuable. The same factors cause China to create an RUK centered on land-based stand-off strike. China's RUK is projectile-intensive and is intended to create anti-access effects in the theater.

Section III identified sensor development as a key factor that influences the interaction of RUKs. Of the two technological trends driving the development of RSCs, the sensor evolution is likely to increase in relative importance while the guided weapons revolution will progress along an asymptote. Simply put, since the theoretical apex of ISR (complete theater awareness; 100 percent probability of detection) is much further off than the theoretical apex of guided weapons (CEP of zero). Thus, the progression of sensor technology and the rate at which each side adopts the technology will be the most important technological factor influencing the nature the reconnaissance-strike competition.

The remaining question, then, is whether the influences exerted by the three top-level asymmetries identified in Section II remain a valid basis for investment in the U.S. RUK. Of specific concern is whether elements of the Chinese RUK change investment incentives for the United States.

In fact, they reinforce existing incentives. China's response to several key elements of U.S. RUK is to increase the density and range of munitions. These are the two key elements of their anti-access network. This results in an increase in the number of targets for the United States in mainland China and the distance over which they can be scattered. The added pressure placed on the U.S. to maximize downrange weapons density reinforces incentives for mobile platforms, which are far more effective than projectiles at dispensing large quantities of ordnance over large areas.

The investment incentives for China are similarly durable. For each of the five critical reconnaissance-strike skills, there are two broad approaches: a platform-intensive approach or a projectile-intensive approach. As Table 9 noted, the United States currently follows a platform-intensive approach for its two skills, and the Chinese follow a projectile-intensive approach for their three skills. There is little incentive to diversify strike profile.

Consider air defense, which should be the easiest case for diversification. Currently the Chinese rely primarily on integrated air defenses as opposed to tactical aircraft tasked for defensive counter-air. That said, China has a substantial and growing investment in tactical aircraft, although these platforms are probably intended for short-range ground strikes. Nevertheless, an attempt to more fully transition to a balanced approach for air defense would be highly risky. In the words of one Wing Commander, “a second-best Air Force is like having a second-best poker hand—adequate for bluffing, but no good at the call.”[81] China might still pour military investment in tactical aircraft, but unless it can reach a tipping point where these forces can achieve air superiority, the investment is likely to yield poor returns in war.

Considering all three first-order causes of asymmetry, the rationale for the U.S. and Chinese RUKs are clear. China’s overall military weakness vis-à-vis the United States prevents it from symmetrically engaging the United States within the theater. Fortunately for China, symmetric engagement would be inefficient from a perspective of geography and unnecessary from a perspective of military victory. Thus, the Chinese response to differential strategic opportunities is an attempt to control the maritime theater from the continental periphery. The U.S. counter-response is to exploit the global commons with even more advanced mobile strike platforms.

[81] Andrew Brookes, quoted in Robert V. Jackson, “The Future of Small Air Forces and Combat Aircraft,” thesis, Air University, April 2001, p. 21.