



A Low-Visibility Force Multiplier

ASSESSING CHINA'S CRUISE MISSILE AMBITIONS

Dennis M. Gormley, Andrew S. Erickson, and Jingdong Yuan

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Cover photo: Missile launch from Chinese submarine during China-Russia joint military exercise in eastern China's Shandong Peninsula.

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Foreword

Reflecting lessons learned from the U.S. deployment of two aircraft carriers during the March 1996 Taiwan Strait crisis, China's military modernization includes ambitious efforts to develop weapons that might deter or delay intervention by outside powers. China views these weapons as part of a broader counterintervention strategy. Western analysts refer to them as antiaccess/area-denial capabilities and have written extensively about their implications for U.S. military freedom of action in the Western Pacific and for the U.S. ability to intervene in the event of a Chinese attack on Taiwan.

Most of this analysis has examined Chinese attack submarines and ballistic missiles; some has focused on Chinese efforts to develop an antiship ballistic missile that might target U.S. aircraft carriers. One area of relative analytical neglect involves China's extensive efforts to develop and deploy large numbers of highly accurate antiship cruise missiles (ASCMs) and land-attack cruise missiles (LACMs) on a range of ground, naval, and air platforms. Although a few articles have examined Chinese cruise missile capabilities and development programs, there has been no comprehensive study on the subject.

The Center for the Study of Chinese Military Affairs (CSCMA) in the Institute for National Strategic Studies at the National Defense University commissioned this book to fill this gap in the open-source literature on the People's Liberation Army (PLA). The book helps fulfill the CSCMA's congressionally-mandated mission "to study and inform policymakers in the Department of Defense, Congress, and throughout the Government regarding the national goals and strategic posture of the People's Republic of China and the ability of that nation to develop, field, and deploy an effective military instrument in support of its national strategic goals."

The authors combine extensive individual expertise in cruise missiles, arms control, and nonproliferation, Asian security, the Chinese military, and the Chinese defense industry. Dennis Gormley, a Senior Lecturer at the University of Pittsburgh's Graduate School of Public and International Affairs, is an internationally recognized expert on cruise missiles. Jingdong Yuan, an Associate Professor in the Centre for International Security Studies at Sydney University, is an expert on arms control and nonproliferation who has written widely on Asian security issues. Andrew Erickson, an Associate Professor in the Strategic Research Department at the U.S. Naval War College and a founding member of the department's China Maritime Studies Institute, is widely recognized as one of the best young analysts studying the PLA and Chinese defense industry.

Their combined efforts have produced this comprehensive study, which addresses the historical origins of the Chinese cruise missile program, considers progress made in developing and deploying ASCMs and LACMs, and reviews Chinese doctrinal writings to consider how these weapons might be employed in a conflict. The authors make

extensive use of Chinese military and technical writings to assess current Chinese capabilities and identify potential future directions for Chinese cruise missile development and employment.

I was fortunate to have had the privilege of working closely with all three authors to bring this book to fruition. My work as editor has involved formulating the terms of reference for the original study, providing substantive guidance in restructuring the manuscript, undertaking several complete revisions to incorporate additional Chinese sources and smooth the prose, and overseeing the painstaking final stage of verifying references and shepherding the book through the clearance and publication process. The result stands as the definitive work on the subject of Chinese cruise missiles.

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Abbreviations

A2/AD	antiaccess/area-denial
AAM	air-to-air missile
AAW	antiair warfare
AESA	active electronically scanned array
AIP	air-independent propulsion
ARM	antiradiation missile
ASAT	antisatellite
ASBM	antiship ballistic missile
ASCM	antiship cruise missile
ASM	air-to-surface missile
ASUW	antisurface warfare
ASW	antisubmarine warfare
ATM	airborne tactical missile
AVIC	Aviation Industry Corporation of China
AWACS	airborne warning and control system
BUAA	Beijing University of Aeronautics and Astronautics
C4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CASC	China Aerospace Science and Technology Corporation
CASIC	China Aerospace Science and Industry Corporation
CATIC	China National Aero-Technology Import & Export Corporation
CCP	Chinese Communist Party
CEP	circular error probable
CMC	Central Military Commission
CMD	cruise missile defense
COMAC	Commercial Aircraft Corporation of China
COSTIND	Commission of Science, Technology, and Industry for National Defense
CPMIEC	China Precision Machinery Import and Export Corporation
CSG	(U.S.) carrier strike group
DOD	Department of Defense
DSMAC	digital scene matching area correlation

Abbreviations

ECM	electronic countermeasure
EM	electromagnetic
EO/IR	electro-optical/infrared
EU	European Union
EW	electronic warfare
GEO	geostationary Earth orbit
GLCM	ground-launched cruise missile
GLONASS	Global Navigation Satellite System
GNP	gross national product
GPS	Global Positioning System
GTD	ground target designation
HALE	high altitude, long endurance
INS	inertial navigation system
ISR	intelligence, surveillance, and reconnaissance
kg	kilogram
km	kilometer
km/h	kilometers per hour
LACM	land-attack cruise missile
LOEC	Luoyang Optoelectro Technology Development Center
m	meter
MEO	medium Earth orbit
MII	Ministry of Industry and Information
MND	Taiwan Ministry of National Defense
MRBM	medium-range ballistic missiles
m/s	meters per second
MTCR	Missile Technology Control Regime
NASIC	National Air and Space Intelligence Center
nm	nautical mile
NORINCO	North Industries Corporation
ONI	Office of Naval Intelligence
OTH	over-the-horizon
OTH-T	over-the-horizon targeting
PAC	Patriot Advanced Capability

PGM	precision-guided munitions
PLA	People's Liberation Army
PLAAF	People's Liberation Army Air Force
PLAN	People's Liberation Army Navy
PNT	position, navigation, and timing
PRC	People's Republic of China
RI	research institute
SALT	Strategic Arms Limitation Treaty
SAM	surface-to-air missile
S&T	science and technology
SASTIND	State Administration of Science, Technology, and Industry for National Defense
SATCOM	satellite communications
SLAM	stand-off land-attack missile
SLCM	submarine-launched cruise missile
SLOC	sea lines of communication
sqm	square meter
SRBM	short-range ballistic missile
SS	conventional submarine
SSN	nuclear-powered attack submarine
TADIL	Tactical Digital Information Link
TEL	Transporter, Erector, Launcher
TERCOM	terrain contour matching
UAV	unmanned aerial vehicle
UCAV	unmanned combat aerial vehicle
UHF	ultra-high frequency

Executive Summary

China's military modernization is focused on building modern ground, naval, air, and missile forces capable of fighting and winning local wars under informationized conditions. The principal planning scenario has been a military campaign against Taiwan, which would require the People's Liberation Army (PLA) to deter or defeat U.S. intervention. The PLA has sought to acquire asymmetric "assassin's mace"¹ technologies and systems to overcome a superior adversary and couple them to the command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) systems necessary for swift and precise execution of short-duration, high-intensity wars.

A key element of the PLA's investment in antiaccess/area-denial (A2/AD) capabilities is the development and deployment of large numbers of highly accurate antiship cruise missiles (ASCMs) and land-attack cruise missiles (LACMs) on a range of ground, air, and naval platforms. China's growing arsenal of cruise missiles and the delivery platforms and C4ISR systems necessary to employ them pose new defense and nonproliferation challenges for the United States and its regional partners. This study surveys People's Republic of China (PRC) ASCM and LACM programs and their implications for broader PLA capabilities, especially in a Taiwan scenario. Key findings are presented below.

The Military Value of Cruise Missiles

- Cruise missiles are versatile military tools due to their potential use for precision conventional strike missions and the wide range of employment options.
- Modern cruise missiles offer land, sea, and air launch options, allowing a "two-stage" form of delivery that extends their already substantial range. They may also be placed in canisters for extended deployments in harsh environments.
- Because cruise missiles are compact and have limited support requirements, ground-launched platforms can be highly mobile, contributing to prelaunch survivability. Moreover, cruise missiles need only rudimentary launch-pad stability, enabling shoot-and-scoot tactics.
- Since cruise missile engines or motors do not produce prominent infrared signatures on launch, they are not believed to be detectable by existing space-warning systems, reducing their vulnerability to postlaunch counterforce attacks.
- The potentially supersonic speed, small radar signature, and very low altitude flight profile of cruise missiles stress air defense systems and airborne surveillance and tracking radars, increasing the likelihood that they will successfully penetrate defenses.

- Employed in salvos, perhaps in tandem with ballistic missiles, cruise missiles could saturate defenses with large numbers of missiles arriving at a specific target in a short time.
- Optimal employment of cruise missiles requires accurate and timely intelligence; suitable and ideally stealthy and survivable delivery platforms; mission planning technology; command, control, and communications systems; and damage assessment.²

Chinese Antiship Cruise Missile Developments

- China, like other nations, has come to regard ASCMs as an increasingly potent means of shaping the outcome of military conflicts.
- China has developed its own advanced, highly capable ASCMs (the YJ series) while also importing Russian supersonic ASCMs, which have no operational Western equivalents.
- China is capable of launching its ASCMs from a growing variety of land, air, ship, and undersea platforms, providing redundant multiaxis means of massing offensive firepower against targets at sea (or at least against their predicted locations).³
- Virtually every new surface ship and conventionally powered submarine in the People's Liberation Army Navy (PLAN) can launch ASCMs, allowing these platforms to serve as "aquatic TELs" (Transporter-Erector-Launchers).⁴ Navy training has become more diverse and realistic in recent years with increasing focus on cruise missile operations.
- Beijing has furnished its ASCMs with improved guidance and has recently begun selling satellite navigation capabilities. Still, over-the-horizon (OTH) targeting remains a challenge.
- Chinese researchers are studying how to best overcome Aegis defenses and target adversary vulnerabilities. ASCMs are increasingly poised to challenge U.S. surface vessels, especially in situations where the quantity of missiles fired can overwhelm Aegis air defense systems through saturation and multiaxis tactics.
- Possible future uses of Chinese aircraft carriers might include bringing ASCM- and LACM-capable aircraft within range of U.S. targets.
- A consistent theme in Chinese writings is that China's own ships and other platforms are themselves vulnerable to cruise missile attack. But China appears to believe it can compensate by further developing its capacity to threaten enemy warships with large volumes of fire.

Chinese Land-Attack Cruise Missile Developments

- China has deployed two subsonic LACMs, the air-launched YJ-63 with a range of 200 kilometers (km) and the 1,500+ km-range ground-launched DH-10. Both systems benefited from ample technical assistance from foreign sources, primarily the Soviet Union/Russia.
- The first-generation YJ-63 employs inertial navigation complemented by an electro-optical terminal sensor to achieve 10–15 meter (m) accuracy.
- The second-generation DH-10 has a GPS/inertial guidance system but may also use terrain contour mapping for redundant midcourse guidance and a digital scene-matching sensor to permit an accuracy of 10 m.
- Development of the Chinese Beidou/Compass navigation-positioning satellite network is partly intended to eliminate dependence on the U.S. GPS for guidance.
- Beijing has purchased foreign systems and assistance to complement its own indigenous LACM efforts. It has received Harpy antiradiation drones with stand-off ranges of 400 km or more from Israel. China may also have the Russian Klub 3M-14E SS-N-30 LACM,⁵ which can be launched from some PLAN *Kilo*-class submarines and deliver a 400-kilogram (kg) warhead to a range of 300 km.⁶
- Time and dedicated effort will increase the PLA's ability to employ LACMs even in challenging combined-arms military campaigns.⁷

Potential Employment in a Taiwan Scenario

- Chinese ASCMs and LACMs could be used in conjunction with other A2/AD capabilities to attack U.S. naval forces and bases that would be critical for U.S. efforts to respond to a mainland Chinese attack on Taiwan.
- Operating in tandem with China's huge inventory of conventionally armed ballistic missiles, LACMs could severely complicate Taiwan's capacity to use its air force to thwart Chinese attack options.
- Chinese military planners view LACMs as particularly effective against targets requiring precision accuracy (for example, airfield hangars and command and control facilities). They also view large-salvo attacks by LACMs and ballistic missiles as the best means to overwhelm enemy missile defenses.
- Chinese planners emphasize the shock and paralytic effects of combined ballistic and LACM attacks against enemy airbases, which could greatly increase the effectiveness of follow-on aircraft strikes. These effects depend significantly on the number of launchers available to deliver missiles.⁸
- China currently has 255–305 ballistic missile and LACM launchers within range of Taiwan, which are capable of delivering sustained pulses of firepower against a

number of critical airfields, missile defense sites, early warning radars, command and control facilities, logistical storage sites, and critical civilian infrastructure such as electrical distribution.

Proliferation Implications of China's Cruise Missiles

- If China's past record of proliferating ballistic missiles and technology is any indication of its intentions vis-à-vis cruise missile transfers, the consequences could be highly disruptive for the nonproliferation regime and in spreading A2/AD capabilities.
- China has sold ASCMs to other countries, including Iran.
- Beijing is suspected of furnishing Pakistan with either complete LACMs or components for local assembly.
- China's lack of adherence to the principles of the 34-nation Missile Technology Control Regime (MTCR) is especially problematic regarding cruise missiles and UAVs.
- China has sought unsuccessfully to become a full member of the MTCR since 2004. However, should China become a fully compliant MTCR member, it would be a salient achievement in limiting widespread LACM proliferation.

Assessment

China has invested considerable resources both in acquiring foreign cruise missiles and technology and in developing its own indigenous cruise missile capabilities. These efforts are bearing fruit in the form of relatively advanced ASCMs and LACMs deployed on a wide range of older and modern air, ground, surface-ship, and sub-surface platforms.⁹ To realize the full benefits, China will need additional investments in all the relevant enabling technologies and systems required to optimize cruise missile performance.¹⁰ Shortcomings remain in intelligence support, command and control, platform stealth and survivability, and postattack damage assessment, all of which are critical to mission effectiveness.

ASCMs and LACMs have significantly improved PLA combat capabilities and are key components in Chinese efforts to develop A2/AD capabilities that increase the costs and risks for U.S. forces operating near China, including in a Taiwan contingency. China plans to employ cruise missiles in ways that exploit synergies with other strike systems, including using cruise missiles to degrade air defenses and command and control facilities to enable follow-on air strikes. Defenses and other responses to PRC cruise missile capabilities exist, but will require greater attention and a focused effort to develop technical countermeasures and effective operational responses.

Introduction and Overview

China's Cruise Missiles as a Stealthy "Assassin's Mace"

Advanced militaries—most prominently, the U.S. military—have demonstrated the considerable utility of cruise missiles in modern war. Chinese analysts have followed technological developments and operational uses of cruise missiles closely and see their considerable military value and operational advantages.¹ They regard cruise missiles as small, difficult to detect and defend against, combat-effective with a high level of precision, compatible with various launch platforms, cost-effective, and having strong penetration capabilities. Many countries acquire and deploy them because of these characteristics. Major powers are developing new generations of cruise missiles that are “serial, integrated, super-sonic, stealthy, high-precision, and smart [系列化, 一体化, 超声速, 隐形化, 高精度, 智能化].”

Missiles have long been Beijing's most potent and well-developed weapons.² “China has prioritized land-based ballistic and cruise missile programs,” according to a 2011 U.S. Department of Defense (DOD) report. “It is developing and testing several new classes and variants of offensive missiles, forming additional missile units, [and] upgrading older missile systems.”³ The report cautions, “The PLA is acquiring large numbers of highly accurate cruise missiles, many of which have ranges in excess of 185 km. This includes the domestically produced ground-launched DH-10 LACM; the domestically produced ground- and ship-launched YJ-62 ASCM; the Russian SS-N-22/Sunburn supersonic ASCM, which is fitted on China's *Sovremenny*-class DDGs acquired from Russia; and, the Russian SS-N-27B/Sizzler supersonic ASCM on China's Russian-built, *Kilo*-class diesel-electric attack submarines.”⁴

Cruise missiles have many advantages over ballistic missiles for China, according to U.S. defense analyst Thomas Mahnken. It is cheaper and easier to make them highly accurate. They require simpler launch platforms and support equipment. They “approach their targets from different azimuths than ballistic missiles [and] hug the ground.”⁵ Many ground-based radars supporting modern air defenses attempt to reduce ground clutter by lifting their search beams above the ground, increasing the chance that cruise missiles will approach undetected. Moreover, the detection range of surface-based radars is limited by the curvature of the earth's surface.”⁶ Finally, “Most modern ASCMs and LACMs also have sleek aerodynamic designs that make them difficult to detect. Their reduced

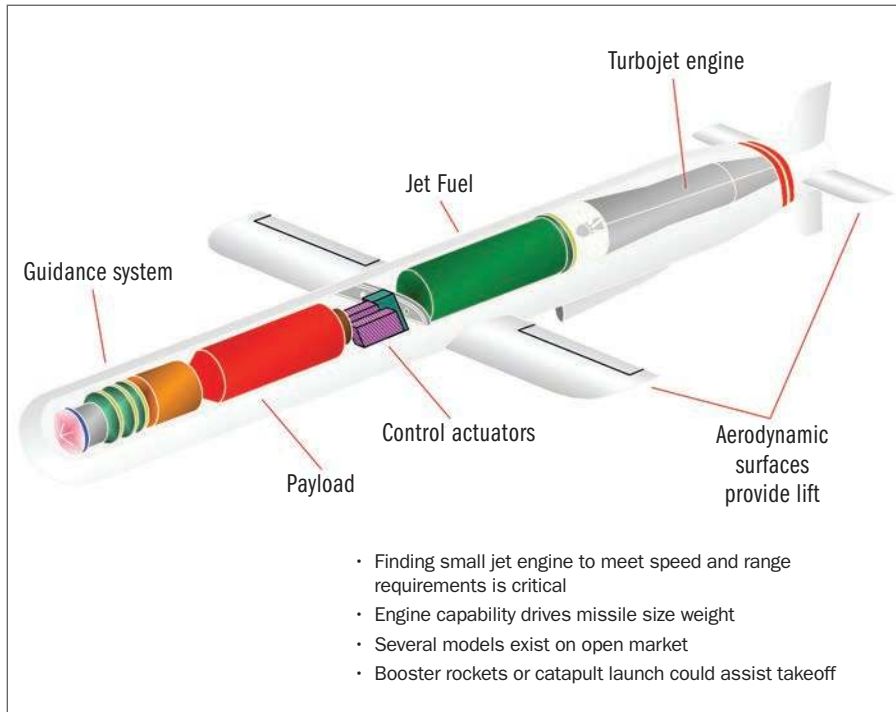
radar cross section means that missile defenses will find detection more difficult, further reducing reaction time.⁷

That said, cruise missiles do have a variety of relative disadvantages including much longer flight times (with obvious implications for mobile targets); the need to fly long ranges at high altitudes⁸ where they are more vulnerable to being shot down; low operational ceilings at long ranges (thus making it harder to fly over mountains, important in a Taiwan scenario); shorter maximum ranges than ballistic missiles; and difficulty in identifying moving targets correctly.⁹ According to a Chinese source, fake targets can deceive cruise missiles, and their target scope and damage potential are limited.¹⁰

Chinese observers point out that the 1991 Gulf War began the new era of modern warfare, ending the so-called “mechanized” warfare of the two World Wars and beginning high-tech modern “informatized” warfare. In this context, the use of cruise missiles became virtually synonymous with high-tech war. Almost all U.S. military interventions in the 1990s began with Tomahawk cruise missile strikes that employed precision, stealth, and lethality to hit distant targets. Whoever possesses such capabilities may be able to seize the initiative and launch preemptive surgical strikes.¹¹

In contrast to their ballistic counterparts, cruise missiles are essentially pilotless airplanes that use aerodynamic lift to remain airborne, thereby demonstrating sustained aerodynamic flight, until they strike their target. They are self-navigating missiles, although some advanced models use data links to update or change preplanned targeting instructions. Cruise missiles can fly at very low altitudes to avoid radar detection. Supersonic cruise missiles with ranges beyond roughly 50 nautical miles (nm) have to fly high to conserve fuel for at least part of the profile—generally the early part until they drop below the radar horizon—or do a very steep dive into the target. There are a number of different types of long-range supersonic cruise missiles as well as some hybrid (subsonic/supersonic) models. Unlike UAVs, which can be reused, cruise missiles are single-use systems. Land-attack and antiship cruise missiles are similar in that they are comprised of three main components: a propulsion system, a guidance and navigation system, and a payload, as illustrated in figure 1. These components are housed in an airframe with small wings and a tail assembly, which provide lift and stability during flight.

Performance of a cruise missile engine determines maximum speed, and engine efficiency influences maximum range. The China Aerospace Science and Industry Corporation (CASIC) Third Academy, China’s primary researcher, developer, and manufacturer of cruise missiles, classifies them as short-range (50 km or less), medium-range (50–120 km), medium-long-range (120–500 km), long-range (500–5,000 km), very-long-range (5,000–8,000 km), and intercontinental (above 8,000 km).¹² Basic cruise missiles use turbojet engines while advanced models use turbofan engines. Generally speaking, most LACMs employ either a turbojet or turbofan engine. To achieve ranges beyond around

Figure 1. Elements of a Cruise Missile

Development of a reliable and efficient long-range turbofan or turbojet remains the most challenging task associated with cruise missile development. Engine design and manufacture require a tremendous array of industrial and scientific aerospace skills. Only a few countries have demonstrated the scientific and industrial capacity to produce such systems. Proper design is particularly critical for engines powering longer-range or large payload cruise missiles and requires a range of disciplines in metallurgy, air flow dynamics, heat transfer, hydraulics, mechanical engineering, and perhaps computer-aided design techniques.

500 km, LACMs must be equipped with more advanced high-bypass turbofan engines. These engines are more fuel efficient at subsonic speeds than turbojet engines, which are most efficient (if range-limited) at supersonic speeds. Ramjet engines can propel missiles to around Mach 5 in principle and nearly Mach 3 in practice today. They are now used in some ASCMs and LACMs, albeit at a high altitude for at least part of the flight if they have ranges in excess of 50 to 60 nm (range varies by missile size). A small booster rocket is employed on ground-launched and at least some sea-launched cruise missiles to lift the missile off the launcher, after which the engine ignites to achieve aerodynamic flight.

Guidance and navigation differ greatly between ASCMs and LACMs. ASCMs require less complicated guidance and navigation because their flight is over a generally featureless surface (water) against a target (a ship or other metal object). Thus, ASCMs typically use an inertial guidance system for most of their flight coupled with a terminal seeker such as radar. LACMs, by comparison, must deal with low-level flight over often highly variegated

terrain. To accomplish low-level flight under those taxing conditions, modern LACMs typically employ an inertial navigation system, which, because it accumulates errors as a function of time, receives corrective updates from a GPS receiver. During the Cold War, U.S. and Soviet LACMs depended on terrain contour matching (TERCOM) technology, which involved the use of a radar altimeter in the missile's nose to sense the terrain over which the missile flew and to compare it with pre-recorded mapping data stored in the flight control system to achieve course corrections. TERCOM is often still employed today in LACMs as a backup or primary means of accurate navigation, as satellite navigation signals may be jammed. Finally, some advanced LACMs use digital scene matching area correlation (DSMAC) technology, which essentially employs a camera and image correlator with pictures of the target as seen from different perspectives. DSMAC permits LACMs to achieve accuracies of about 1 m. Other (for example, thermal) sensors can be employed to achieve sufficient terminal accuracy.

A key advantage of cruise missiles is their ability to be fired from multiple platforms, allowing for flexibility and customization. Exploiting this possibility entails challenges, however, as further specialization and performance tradeoffs may be necessary to adapt cruise missiles to given platforms. Ground-launched cruise missiles (GLCMs), which stem from the early days of PRC coastal defense, do not require complex and difficult-to-defend platforms. Their launchers may be mobile and can only be destroyed through potentially escalatory strikes against mainland Chinese territory. While the greatest disadvantage of GLCMs is distance from potential targets, China's newest LACM variants have range sufficient to hit targets on Taiwan and beyond. Naval platforms offer the advantage of persistent presence (potentially unchallenged, at least before hostilities erupt) in closest proximity to potential targets on China's maritime periphery, thereby making maximum use of ASCMs' limited ranges. China's imported *Sovremenny*-class destroyers and indigenous destroyers and frigates boast increasingly capable area air defenses that can help protect them from at least a modest attack. Far more concealable, and hence more survivable, are China's newer nuclear and conventionally powered submarines. The latter—which include increasingly competent *Song*-class diesels, *Yuan*-class submarines outfitted with air-independent propulsion (AIP), and advanced *Kilos* imported from Russia—appear to be very quiet¹³ and hence difficult to detect when not using diesel engines to recharge batteries. Chinese conventional submarines appear to be outfitted for an antisurface warfare mission showing potential loadouts that are light on torpedoes and heavy on ASCMs, with one Internet photo anecdotally showing a 3:1 ratio. Air platforms might be more formidable still given their speed and maneuverability. While strike fighters have improved rapidly in recent years, both strike fighters and bombers have been fitted with much-improved weapons systems (for example, advanced cruise missiles); however, this approach remains handicapped by the lingering backwardness

of China's military aviation sector. With regard to a Taiwan contingency, however, the bar for operational success may be lowered significantly by the Second Artillery, whose accurate submunition-equipped short-range ballistic missiles (SRBMs) could rapidly render Taiwan's runways inoperable and, hence, make the airspace over the island and the Strait far less contested.¹⁴

Not only is the PLA training to launch cruise missiles from multiple platforms; many surface vessels and conventionally-powered submarines are also taking ASCM delivery as their priority operational roles. China's Type 022 *Houbei* missile catamaran, for instance, may even be envisioned as an expendable platform with no role other than to deliver ASCMs. As the Office of Naval Intelligence (ONI) emphasizes, "The PLA[N] has more than quadrupled the number of submarines capable of firing . . . ASCM[s], installed missiles with longer ranges and more sophisticated guidance packages on its surface combatants, [and] built over 50 high-speed ASCM[s] carrying patrol craft. . . ."¹⁵

China faces a variety of threats in its security environment that cruise missiles promise to help neutralize. In the 2011 DOD report's assessment, "China is fielding an array of conventionally armed ballistic missiles, modern aircraft, UAVs, ground- and air-launched land-attack cruise missiles, special operations forces, and cyber-warfare capabilities to hold targets at risk throughout the region."¹⁶ Like ballistic missiles, cruise missiles can help with "counterintervention" to support a strategy of "active defense" in the Chinese lexicon or "anti-access/area denial (A2/AD)" in the American. This entails developing the ability to hold most types of proximate military platforms and weapons systems at risk in the event the United States and its allies attempt to intervene in a crisis on China's maritime periphery. As DOD's 2011 report describes it, "China's A2AD focus appears oriented toward restricting or controlling access to the land, sea, and air spaces along China's periphery, including the Western Pacific. For example, current and projected force structure improvements will provide the PLA with systems that can engage adversary surface ships up to 1,850 km from the PRC coast. These include:

- conventional (SS) and nuclear-powered (SSN) attack submarines: *Kilo*-, *Song*-, *Yuan*-, and *Shang*-class attack submarines capable of firing advanced ASCMs
- surface combatants: *Luzhou*-, *Luyang I/II*-, *Sovremenny II*-class guided missile destroyers with advanced long-range antiair and antiship missiles
- maritime strike aircraft: FB-7 and FB-7A, B-6G, and the SU-30 MK2 armed with ASCMs to engage surface combatants."¹⁷

The most likely scenario involves Taiwan; however, Beijing's preference is to rely on cruise missiles and other weapons to enhance deterrence rather than to wage a risky war. Using coercive military capabilities to deter Taiwan from making any moves toward

independence is the preeminent requirement. Inhibiting the U.S. projection of military power into China's sphere of influence more broadly has become a key goal. Here, being able to threaten U.S. naval forces as well as inhibit U.S. use of bases in such locations as Japan, Korea, the Philippines, and Guam through ballistic and cruise missile strikes on airfields, command and control facilities, and logistical bases is a compelling rationale for missile acquisition. The PLA has equipped its bombers with long-range cruise missiles that can threaten U.S. bases in Japan. Chinese cruise missile development promises to address both goals as part of a larger and increasingly successful effort to leverage asymmetrical military capabilities that pit Chinese strengths against U.S. weaknesses stemming in part from the laws of physics.

Chinese planners have come to regard both antiship and land-attack cruise missiles as potentially playing a significant role in determining the outcome of future conflicts. Researchers at the PLA Air Force (PLAAF) Engineering Academy state that "Actual battles have demonstrated that . . . cruise missiles have long range, high precision, strong defense-penetration capability [and] relatively high cost effectiveness," and have already become a "major air raid weapon [主要空袭兵器]" that is used in large quantities for aerial attack.¹⁸ Another study adds that they are "small . . . and highly maneuverable."¹⁹ According to professors at the academy's Missile Science Institute, "The cost of one . . . cruise missile is in the range of one million U.S. dollars while an aircraft costs up to several tens of millions, and the advantage in the performance to cost ratio of missiles is unmistakable."²⁰ Some sources even claim that cruise missiles are superior to ballistic missiles for certain missions, particularly in the areas of general use, agility, and target selection.²¹ The short flight time of supersonic cruise missiles reduces their chances of being shot down and increases their chances of survival and mission fulfillment.²² In what appears to be a particularly nuanced and considered analysis, researchers at the PLA Electronic Engineering Academy conclude: "Even if they are discovered, the time left for defense systems to respond is very short, which makes interception difficult. By pre-set programs, they can go around fixed air defense positions and hit the targets from the side or from behind. Cruise missiles have therefore become the ordnance of first choice for the prelude to open conflict."²³ Chinese analysts carefully monitor both foreign weapons developments and Western assessments of their own programs. One article notes that "According to Western observers, China's development of cruise missile technology has been extremely fast."²⁴ Still, in the larger context, this observation is in concert with widespread assessments favoring such asymmetric weapons as submarines, ballistic missiles, and sea mines over rapid and high-volume development of more complex and potentially provocative aircraft carriers. Chinese analysts assess that cruise missiles will not create undue political risk, thereby allowing military modernization to stay, for the most part, below the geopolitical radar. But these relatively low-visibility Chinese military

developments deserve deeper exploration. To that end, this study assesses the emerging roles and capabilities of Chinese antiship and land-attack cruise missiles and how they could enhance warfighting capabilities.

Chapter 1 focuses on the institutional and organizational players engaged in producing China's cruise missile programs. This chapter covers not only high-level organizations and the roles they play, but also the physical facilities and their locations as well as the human capital devoted to cruise missile development (where such information is available). Written from a historical perspective, this chapter provides insight into the critical role that outside states, most notably the Soviet Union/Russia, have played in China's cruise missile programs. Chapter 2 analyzes the characteristics and capabilities of ASCM programs. Chapter 3 turns to the more recent emergence of LACMs. While the bulk of chapter 3 focuses on LACM developments with particular attention to outside state assistance and the transformation of ASCMs into LACMs, the chapter also addresses China's growing interest in UAVs, which may have the potential to enhance the effectiveness of cruise missiles in land campaigns. Chapter 4 examines the platforms that may be used to launch cruise missiles and their performance parameters. Chapter 5 reviews Chinese cruise missile employment doctrine and training. Chapter 6 assesses the potential of China's cruise missiles—land and sea variants alike—to contribute to PLA campaigns and missions. Rather than providing a detailed quantitative campaign analysis, the chapter offers an overview of the unique contributions that cruise missiles offer, using a hypothetical contingency involving armed conflict with Taiwan and U.S. military involvement therein as an illustration of how cruise missiles might offer a potent addition to China's military capabilities. Because such contributions are impossible to ascertain without considering how cruise missiles interact with other Chinese military forces, this chapter also devotes analytical attention to the combined effects of using various air, ground, and sea assets to deliver firepower against sea targets as well as the synergistic effects of combined use of land-attack cruise missiles and ballistic missiles against ground targets. Chapter 7 assesses the potential for China to proliferate cruise missiles and related technology, particularly in light of its tenuous obligations as an adherent to the principles of the 34-nation MTCR. Finally, chapter 8 summarizes the study's findings and offers projections for the future.

Institutional and Organizational Actors in China's Cruise Missile Programs

China began introducing surface-to-air missiles (SAMs) and antiship cruise missiles (ASCMs) into its inventory in the late 1950s.¹ Following the February 1950 Treaty of Friendship, Alliance, and Mutual Assistance and the first Five-Year Plan for industrial and agricultural development and production (1953–1958), and soon after the signing of the 1958 bilateral accord on defense cooperation, the Soviet Union transferred Type 542 shore-to-ship and Type 544 (P-15/Styx SS-N-2) antiship missiles and SA-2 SAMs to China.² Despite the departure of Soviet advisors in September 1960 in the wake of the Beijing-Moscow fallout, the Chinese persevered and conducted their first successful missile test in November 1960.³

The Soviets provided China with the first batch of cruise missile models and technical data in 1959 in accordance with the October 1957 Sino-Soviet New Defense Technical Accord and the February 1958 bilateral agreement, which specified that the Soviet side would assist with China's missile programs, including supplying the Type 542 KS-1 and Type 544 P-15/Styx SS-N-2 ASCMs.⁴ The Fifth Academy under the Ministry of Defense was assigned the lead role in coordinating national efforts in ASCM research, design, and licensed production. Established on October 8, 1956, and with the late Qian Xuesen (Tsien Hsue-shen) as its first director, the Fifth Academy was instrumental in China's cruise and ballistic missile developments.⁵

Office No. 40 and an assembly line for ASCMs were set up in the Nanchang Aircraft Manufacturing Company in 1960 to initiate production. Even before the cruise missiles were manufactured, the Central Military Commission instructed the PLA Navy (PLAN) Headquarters to select an ASCM test site. In March 1958, the test site was chosen at Liaoxi in Liaoning Province. Many of China's ASCM tests, such as those for Shang You-1 and the Hai Ying-series, were undertaken at the Western Liaoning site.⁶ Production began in October 1963. In August 1964, China's first ASCM, a license-produced version of the Soviet P-15 Termit (NATO designation: SS-N-2A "Styx"), passed factory tests. A year later, the first missile test was successful. Subsequent tests led to further improvements, and in August 1967 the missile, designated Shang You-1 (SY-1), was approved for production and entered service in the late 1960s. An indigenously improved version, Hai Ying 1 (HY-1 or "Sea Eagle"), was successfully tested in December 1968 and entered service in

1974. In October 1969, Premier Zhou Enlai reportedly approved the establishment of a Military Industry Enterprise Base to produce antiship cruise missiles.⁷

The Soviet P-15 cruise missile provided the basic foundation for future development of more advanced ASCMs and eventually LACMs. Other derivatives from the Soviet P-15 include the HY-2 and HY-4. The Third Academy also designed a series of derivatives including the Ying Ji 1 (“Eagle Strike”) (YJ-1), YJ-61, YJ-8 series, and YJ-62, all of which were manufactured at the Xi’an Aircraft Factory.

The U.S. military’s early-stage cruise missile research and testing success caught the PLA’s attention. In addition, the PLA reportedly viewed cruise missiles as part of a military development plan to deter military, particularly nuclear, attack from the Soviet Union, believing that cruise missiles were vital to the affirmation of China’s technological and economic development status. Chinese military experts further argued that LACMs could facilitate a rapid increase in PLA combat capabilities by supplementing an outmoded and difficult-to-reform PLAAF. Cruise missiles were perceived to be inexpensive and highly accurate and to represent the most effective way to improve air combat capability. Their technology was perceived to be mature, their guidance and control were relatively simple, and environmental factors did not interfere significantly with their operation.

As part of the country’s efforts to develop an indigenous defense industrial base, cruise missile programs received high-level political support from the beginning. Many decisionmakers in defense industrial matters also occupied top-level government positions, which ensured that weapons programs, both nuclear and conventional, enjoyed access to resources and manpower. Premier Zhou Enlai, Marshals Nie Rongzhen and He Long, and General Luo Ruiqing all played critical roles in the formative years of China’s national defense infrastructure.⁸ The involvement of top leaders not only ensured that weapons R&D received adequate funding and recruited the best and brightest scientists and technicians, but also that critical weapons programs were protected against the political upheaval of such domestic debacles as the Cultural Revolution. (Appendix A provides a brief history of China’s cruise missile institutes and management structure.)

Compared to the even higher priority strategic nuclear and ballistic missile programs, however, cruise missile development encountered more problems and registered slower progress. It was not until the late 1960s and early 1970s that China was able to produce its own modified derivatives of Soviet-model cruise missiles.⁹ As the subsequent chapter will discuss in further detail, recent years have witnessed noticeable progress in antiship and land-attack cruise missiles such as the YJ-62 ASCM and YJ-63 and DH-10 LACMs. However, it is clear that China continues to rely on foreign, and in particular Russian, technology, for development of cruise missiles. Beijing may also have benefited from Ukrainian Kh-55 LACMs reportedly transferred in 2005.¹⁰

China has tried a variety of approaches to resolve persistent problems in its R&D and defense production. These include moving from numbered ministries to corporations; efforts to encourage competition (with mixed results); and separation of military requirements and evaluations (General Armaments Department) from civilian defense industry management and production (formerly the Commission of Science, Technology, and Industry for National Defense, COSTIND; and now the new State Administration of Science, Technology, and Industry for National Defense, SASTIND). Problems and obstacles persist in cruise missile programs and, for that matter, in the country's overall conventional weapons innovation and development. Tai Ming Cheung, in his detailed study of China's defense economy, identifies seven major barriers: compartmentalization, decisionmaking fragmentation, rigidity as a result of central planning, insufficient information sharing, lack of incentives for innovation and protection of intellectual property rights, the dispersed nature of many research and production facilities, and political infighting.¹¹ While reorganizing the defense management structure in the 1980s and 1990s helped mitigate some of these problems, the reorganization's significance lies more in reducing unneeded personnel and changing the bureaucratic structure than acting as a direct stimulus for innovation.

Indeed, through much of the 1960s and 1970s, a number of organizations either under the State Council or the Central Military Commission (CMC) managed defense R&D and production and coordinated between the civilian sectors and the military, which set procurement requirements. It was not until July 1982 that the National Defense Industry Office, the National Defense Science and Technology Commission, and the Office of the Science, Technology, and Equipment Committee of the CMC were merged into a single ministerial-level agency, COSTIND. Subsequently, during the major reform of the government and defense industries in 1998, COSTIND was separated into a civilian commission and a military General Armament Department. For many years, COSTIND and its many predecessor variants have served as the key coordinating and supervisory agency in China's defense science and technology R&D and manufacturing complex. At one point, it oversaw a defense industrial conglomerate consisting of 50,000 factories, research institutes, and academies with over five million personnel.¹²

The separation of the military and civilian components of COSTIND was part of the efforts to reform the defense industry's management and create a more competitive environment in which the old COSTIND could no longer dictate both what was produced and what was to be provided to the PLA. The newly created General Armament Department became the military's procurement agency and could demand better quality, timely delivery, and parts and services from the country's defense industry that, having lost monopoly control of production and supply of items to the PLA, now has to meet military requirements. At the same time, the five line ministries responsible for overseeing

weapons R&D and production were dissolved in the 1980s and restructured into five state-owned enterprises. In 1999, these were further reorganized into 11 defense industrial conglomerates. These are typically state-owned enterprises but carry ministerial rank and therefore have significant bureaucratic authority.¹³

The government agency currently responsible for coordinating defense industry R&D and production is SASTIND. COSTIND was dissolved at the 11th National People's Congress in March 2008, and the new SASTIND is under a newly created super ministry, the Ministry of Industry and Information (MII). Chen Qiufa, a former COSTIND deputy director, was appointed SASTIND director as well as a Vice Minister of MII.¹⁴ The full impact of this organizational change, which effectively lowered SASTIND's rank to that of a bureau-level entity and also assigned some of the COSTIND's responsibilities to other newly created government ministries, remains to be seen, especially where cruise missile R&D and production are concerned.¹⁵

Acquisitions of foreign military technologies represent a critical approach to improving China's defense industry, which was built in the 1950s with Soviet assistance through massive imports of plants, prototypes, blueprints, training, and organization and management structure. By the late 1970s, when economic reforms were implemented, China had established an enormous defense industrial base that contained about 25 percent of the country's heavy industrial capacity and produced 10 percent of its gross national product (GNP).¹⁶ However, quantitative growth had not been accompanied by qualitative progress. Most of the weapons the Chinese defense industry manufactured were based on Soviet prototypes of 1950s and early 1960s vintage. In overall terms, China's defense industrial base and military technology base remained weak and had been further undermined by the process of economic reforms that began in the late 1970s.¹⁷ The post-Cold War period has seen significant spending on major Russian weapons systems. However, Beijing is more interested in acquiring military technologies from Russia and elsewhere to enhance its now rapidly growing indigenous defense industrial capabilities.¹⁸ With the United States and the European Union continuing their post-Tiananmen arms bans on China, Russia remains the most prominent provider, particularly given the past ties between the two countries in the defense industrial sector.

China has adopted a number of approaches toward acquiring military technologies from Russia.¹⁹ One is to seek licensed production. Transfers of technology and technical expertise from Russian defense manufacturers have proven instrumental in Chinese development of major weapons systems. For example, a 1995 agreement allowed China to produce 200 Su-27s at its Shenyang aircraft factory. The technology and expertise gained through licensed production eventually allowed Chinese experts to reverse engineer the aircraft and produce the Sukhoi-27-derived J-11.

A second approach is to have Russian defense technicians work in Chinese defense research institutes and factories. It has been widely reported that as many as 2,000 Russian technicians have been employed to work on laser technology, nuclear weapons miniaturization, cruise missiles, space-based weaponry, and nuclear submarines.²⁰

A third approach involves many Chinese defense technicians going to Russia to train or to work in aerospace R&D centers. However, Sino-Russian military cooperation may have encountered significant obstacles in recent years as partly reflected by a steep decline in Chinese orders. This may be due in part to growing concerns over what Russia perceives as rampant and illicit Chinese copying and reverse engineering of key weapons systems. Indeed, the Chinese J-11B is a reverse-engineered Su-27 that incorporates indigenous technologies, components, and weapons (for example, the Type 1474 serial radar system and PL-12 air-to-air missiles).²¹ Russian President Dmitry Medvedev reportedly had sought agreement with his Chinese counterpart on protecting Russian defense intellectual property rights.²²

China's cruise missile design, research, development, and manufacturing are concentrated in a single business division within one of two state aerospace conglomerates, the CASIC Third Academy (see Appendix B for complete details). The Third Academy is China's principal R&D and manufacturing entity for cruise missiles; all others are secondary.

Also known as China Haiying [Sea Eagle] Electro-Mechanical Technology Academy (中国海鹰机电技术研究院), the Third Academy was established in 1961 and has been engaged in research, design, development, and production of 20 types of cruise missiles. It has 10 research institutes and two factories, with over 13,000 employees, including 2,000 researchers and senior engineers and 6,000 technicians.²³ It has produced the HY- and YJ-series antiship missiles including the export versions C-801/C-802. The Third Academy is one of the seven design academies under CASIC (中国航天科工集团公司), which has a total of over 100,000 employees.²⁴

The central organization within CASIC responsible for cruise missile systems engineering and design is the Third Academy's 3rd Department, also known as the Beijing Institute of Electro-Mechanical Engineering (北京机电工程研究所). Established in 1960, the department conducts general cruise missile industrial planning, as well as conceptual design and preliminary research. The 3rd Department coordinates with subsystem design shops responsible for engine, guidance, navigation, control, terminal guidance, software development, and manufacturing. The Third Academy's 31st Research Institute (Beijing Power Machinery Institute, 北京动力机械研究所) oversees cruise missile engine subsystem design and development. Established in 1965, the 33rd Research Institute (Beijing Institute of Automated Control Equipment, 北京自动化控制设备研究所) designs, develops, and tests cruise missile-related navigation, guidance, and control systems. Located in Beijing's southwestern suburbs, the Third Academy's 159 Factory (Beijing Xinghang

Electromechanical Equipment Factory, 北京星航机电设备厂) is the primary assembly plant for antiship and land-attack cruise missiles.²⁵

Another corporate-level entity that has attempted to enter the cruise missile market is the Hongdu Aviation Industry Group (洪都航空工业集团有限责任公司, or 洪都集团). Also known as the Nanchang Aircraft Manufacturing Company, the enterprise produced the early versions of Chinese ASCMs such as the SY-, HY-, and YJ-series and the Feilong (“Flying Dragon”) export series based on the SY series. Established in 1951, the Hongdu Group has developed major products in military aviation including F-6, A-5, and K-8 trainer aircraft and the HY- and SY-series of ASCMs.²⁶ The group has its own cruise missile research and design institute. China National South Aeroengine Company (formerly known as the Zhuzhou Aeroengine Factory) manufactures the turbojet engines for ASCMs. Both Hongdu and South Aeroengine are under the Aviation Industry Corporation of China (AVIC).²⁷

The China Precision Machinery Import and Export Corporation (CPMIEC, 中国精密机械进出口公司), a member of the Xinshidai (New Era) Group and jointly owned by the Chinese Aerospace Science and Technology Corporation (CASC) and CASIC, was established in 1980.²⁸ CPMIEC is the export management branch of the CASIC Third Academy. It is the export/import arm for various Chinese-made weapons systems including ASCMs. It reportedly has marketed for export the following types of cruise missiles: SY-1 (CSS-N-1), YJ-1/C-101(CSS-X-5), HY-1 (CSS-N-2/CSSC-2), HY-2/C-201 (CSSC-3), HY-4/C-201 (CSSC-7), C-201W, HY-3/C-301, YJ-6/C-601 (CAS-1), YJ-8/C-801, YJ-83/C-802.²⁹ Other companies that have been implicated by the U.S. Government as being involved in cruise missile transfers include the China North Industries Corporation (NORINCO, 中国北方工业公司) and the China National Aero-Technology Import & Export Corporation (CATIC, 中国航空技术进出口总公司).³⁰ (For detailed information concerning Chinese cruise missile development facilities, see Appendix A.) The most important corporations involved in cruise missile production and export are listed in table 1.1.

Table 1.1. Key ASCM-/LACM-production and Export/Import Organizations

Name	Affiliation	Location	Role
Third Academy/China Hai Ying [Sea Eagle] Electro-Mechanical Technology Academy	CASIC	Beijing	ASCM, LACM production
Hongdu Aviation Industry Group	AVIC	Nanchang, Jiangxi	ASCM production
China Precision Machinery Import and Export Corporation	CASC/CASIC	Beijing	ASCM/LACM export



AP/Wide World Photos

YJ-83A/C-802A ASCM on display at 2008 Zhuhai Airshow



AP/Wide World Photos

PLAN ships fire YJ-8 series ASCMs in 2007 South China Sea exercise



PLA Navy sailor stands on deck of a *Jiangkai* frigate with YJ-83 ASCM canister launchers



Type-022 *Houbei*-class catamaran firing one of its eight YJ-83 ASCMs



YJ-62 ASCM being launched by transporter erector launcher



JH-7A fighter-bomber carrying KD-88 LACMs and drop tanks



DH-10 LACM transporter erector launchers in 2009 Beijing parade



H-6K bomber carrying CJ-10 LACMs

Characteristics and Capabilities of China's Antiship Cruise Missiles

PLA Navy ASCM Inventory¹

This chapter surveys the importance of ASCMs for modern naval combat, the types of ASCMs China possesses, their heritage and development, and their performance parameters. China has succeeded in importing and producing—both under license and not—a wide range of Soviet/Russian cruise missiles as well as developing its own variants. Less clear is the extent to which the PLA has prepared to integrate cruise missiles into complex combined arms or joint campaigns by practicing battle damage assessment and strengthening C4ISR hardware and software through operational deployment and exercises.

China's ability to deploy ASCMs with sophisticated performance parameters forces potential opposing navies to be able to defeat those missiles, which may be very difficult. An ASCM that is supersonic and sea-skimming in its terminal phase, for instance, will evade the detection of a ship and its missile defenses until it breaks the radar horizon approximately 16–18 nm away, leaving little time for the target to react. The U.S. Navy would have to employ a variety of complex, layered, hard and soft measures. Hard measures involve using missiles such as the vertically-launched SM-2 to attempt to shoot down incoming cruise missiles. Soft measures involve point defense using chaff blooms and electronic countermeasures (ECM). Targeted spoofing measures such as ECM are particularly challenging as they require knowing and exploiting the incoming missile seeker's radar and homing logic. For all these reasons, Chinese ASCMs impose significant peacetime costs on potential opponents who must develop countermeasures, and they could greatly complicate the operation of enemy maritime forces in wartime.

With regard to overall cruise missile development, China has perhaps made the greatest progress regarding ASCMs. Here Beijing has truly developed comprehensive indigenous capabilities that approach world-class levels in many areas. As the 2011 DOD report emphasizes, "The PLA Navy has or is acquiring nearly a dozen ASCM variants, ranging from the 1950s-era CSS-N-2 to the modern Russian-made SS-N-22 and SS-N-27B. The pace of ASCM research, development, and production within China has accelerated over the past decade."² This progress offers not only increasingly effective means to threaten U.S. carrier strike groups (CSGs) and other surface platforms, but also supports future missile development financed by potential international commercial sales (and possible codevelopment, for example, with Iran).³ In the analysis of William S. Murray at the Naval War College, the PLAN, rather than focusing on torpedoes as foreign historical

examples might suggest, is likely “committed to conducting ASUW [antisurface warfare] via attack by antiship cruise missiles.”⁴

China builds its own indigenous ASCMs for the PLAN and for export. PLAN ships and submarines purchased from Russia are equipped with more advanced Russian ASCMs. China has used land-based ASCMs for coastal defense since the 1960s and began to deploy air-launched ASCMs in the late 1980s.⁵

PLAN ASCM programs include a variety of surface, subsurface, and air-launched weapons. This mixture of ASCMs gives the PLAN flexibility and tactical depth and the capacity to employ sub- and supersonic speeds, short and extended ranges, and various warhead packages. The precise total of ASCMs in China’s inventory is unavailable in open source documents; however, estimates from available data and specifications indicate an arsenal in the several thousands. One Chinese analyst suggests that once new reconnaissance and navigation systems are in place, China’s ship-borne cruise missiles would theoretically acquire global strike capabilities.⁶

Pictures of China’s YJ-62, YJ-8 variants, and YJ-83 ASCMs appear regularly on the Internet. These missiles, according to *Jane’s*, are all long-range, potent, and perhaps most importantly indigenously developed.⁷

At the lower end of China’s cruise missile capabilities, the YJ-7 (export designation: C-701) 117 kg compact missile with its 30.5 kg high-explosive semi-armor piercing warhead can be launched from small attack craft, helicopters, or land-based vehicles to a distance of up to 25 km (13.4 nm), where the C-701T export variant would engage its target using electro-optical signals and the C-701 AR export variant with active radar.⁸

The YJ-8 (C-801) and YJ-83 (C-802) series is currently the backbone of China’s antiship missile inventory. Strongly resembling France’s MM38/MM39 Exocet, the YJ-8/C-801 (CSS-N-4 “Sardine”) series may be ship-, submarine-, and air-launched and is used by the PLAAF’s JH-7/A fighter and the PLAN’s *Song*-class submarine.⁹ The most widely deployed surface variant is the YJ-8A, which features folding wings. The YJ-81 is an air-launched variant, and the YJ-82 is a submarine-launched variant.¹⁰ It has a flight speed of Mach 0.9 and an operational range of 42 km.¹¹ The YJ-8 carries a 165 kg semi-armor-piercing warhead of the same size as the Exocet. There are numerous instances of that size warhead disabling destroyers and frigate-sized warships.¹²

Developed by CASIC’s Third Academy, the YJ-83 (C-802) is based on the YJ-8 but employs a different rocket motor, a turbojet with paraffin-based fuel. The YJ-83 has been in service on PLA Navy surface vessels for more than 20 years. It was flight tested in 1990 and, according to Western media sources, entered the PLAN inventory in 1994. Its launch weight has been reduced by 100 kg (warhead mass remains 165 kg); its range has been increased to 120 km (ground/ship) and 130 km (air), and it employs inertial/active radar for guidance.¹³ Its speed is Mach 0.9, and it skims the sea at an altitude of 20 to 30 m. It

may be launched by ship, ground, and air. The major difference from France's Exocet is the "installation of a rudder flight control system on the bottom (底部安装了舵面飞行控制系统)."¹⁴ The YJ-83 has been improved through a series of variants.¹⁵ A single Iranian-made C-802 (export variant) ASCM fired at an Israeli *Hanit Sa'ar* 5-class missile corvette by Hizballah guerrillas in 2006 killed four sailors and rendered the vessel unprepared to engage in combat operations. In wartime it would have been a mission kill.¹⁶

According to China Precision Machinery Import & Export Corporation (CPMIEC) marketing materials, the YJ-83A, exported as the C-802A, has "strong defense penetrating capability, high hitting accuracy, [a] powerful warhead, [and] easy operation and maintenance." It is designed to attack a 5,000-ton destroyer with a radar cross section of at least 3,000 sqm.¹⁷ The YJ-83A can be launched from air-, ship-, and land-based platforms.¹⁸ It features "multiple flight paths and waypoints, sea skimming flight altitude, multiple antijamming capabilities . . . fire and forget . . . and over-the-horizon attack [capabilities]." The YJ-83A's range is 180 km. It has up to four attacking paths with up to three-way points per path. A booster and turbojet propels it at Mach 0.8–0.9. Its flight altitude is 20 m when cruising and 5 to 7 m in terminal phase. For guidance, it uses a strapdown inertial navigation system (INS) and employs a frequency agility radar and digital control to achieve a single-shot kill probability of 90 percent. Its response time is 9 minutes cold and 30 seconds hot. The YJ-83A is 6.383 m long and .360 m in diameter with a wingspan of 1.220 m and a weight of 800 kg. Its 190 kg semi-armor-piercing blast warhead employs an electromechanical contact delay fuse.¹⁹ Other sources describe this missile as a third variant of the basic YJ-8 ASCM, which features a new high frequency agile radar seeker and employs sea-skimming (20–30 m) during the terminal phase, delivering a 165 kg warhead to ranges up to 180 km (ground, ship) and 250 km (air).²⁰ Another source reports that it "has . . . the ability to receive targeting updates in flight."²¹ ONI states that the range of this YJ-83 variant has been increased to roughly 95 nm (176 km).²²

In September 2005, China unveiled a second-generation variant of the YJ-6 ASCM known as the YJ-62 and exported as the C-602.²³ Propped alongside a much smaller C-802 ASCM, the YJ-62 display model claimed subsonic speeds, striking ships at ranges of up to 280 km against sea targets moving at speeds of less than 30 knots. The YJ-62 rapidly descends to 7 to 10 m above sea level (in up to Sea State 6) to deliver its 210 kg armor-piercing high-explosive warhead at Mach 0.6–0.8, assisted by "an inertial navigation system integrated with GPS updates."²⁴ ONI states that the "subsonic, sea-skimming" YJ-62 has a range of approximately 150 nm and is "designed to sink or disable medium to large size ships."²⁵ According to Scott Bray, former Senior Intelligence Officer-China at ONI, "The YJ-62 is China's most capable indigenously produced ASCM. However, unlike the SS-N-27 Sizzler, the YJ-62 is a sub-sonic missile that does not have a super-sonic sprint vehicle."²⁶

In addition to the YJ-62, China has developed an improved YJ-62A variant with a 400 km range.²⁷ The YJ-62 has been deployed on both ground- and ship-launchers and is currently fitted on China's 8 *Luyang II*-class (Type 052C) destroyers.²⁸ Some 120 units of a YJ-62C variant were reportedly deployed on mobile TELs at Fujian bases for use as coastal defense missiles, a role previously played by HY-1 (85 km range) and HY-2 (95 km range) missiles.²⁹

Table 2.1. PLA Antiship Cruise Missiles (Major Systems)¹

Type	Manufacturer	Launch Platform	Range (km)	Payload (kg)	Speed	Guidance (Inertial/terminal)
YJ-7 (C-701) ²	CASIC Third Academy	Ground, ship air	25	30.5	Subsonic	Electro-optical/active radar
YJ-62 (C-602) and YJ-62A ³	CASIC Third Academy	Ship— <i>Luyang II</i> , ground	280 400 (YJ-62A)	210	Subsonic	Inertial/active terminal guidance
YJ-8 series (CSS-N-4 Sardine/C-801) ⁴	CASIC Third Academy	Ship, submarine (YJ-82), air (YJ-81)	42	165	Subsonic	Inertial/active terminal guidance
YJ-83 (CSS-N-8 Saccade/C-802) multiple variants ⁵	CASIC Third Academy	Ship, ground, air	120 (ground/ship), 130 (air)	165	Subsonic	Inertial/active radar
YJ-83A/J (C-802A) multiple variants ⁶	CASIC Third Academy	Ship, submarine (?), ground, air	180 (ground/ship), 250 (air)	165	Subsonic	Inertial/active radar
YJ-91/KR-1 (Kh-31P) ⁷	Zvezda-Strela, Russia; indigenized by China	Ship, air (PLAAF/PLAN)	15–110	87–90 kg HE blast/fragmentation	Supersonic	Passive/Anti-radiation
AS-13 Kingbolt (Kh-59MK) ⁸	Raduga, Russia	PLAAF Su-30MKK	45–115	320 kg AP HE or 280 kg cluster	Subsonic	Inertial and TV/electro-optical

Type	Manufacturer	Launch Platform	Range (km)	Payload (kg)	Speed	Guidance (inertial/terminal)
SS-N-22/Sunburn 3M80E Moskit; 3M80MVE (improved variant) ⁹	Raduga (Russia)	Ship; Project 956 <i>Sovremenny</i> destroyers; 3M80MVE on Project 956EM <i>Sovremenny</i> destroyers	120 240 (3M80MVE)	300	Supersonic	Inertial/ active/ passive
SS-N-27B/Sizzler ¹⁰	Novator (Russia)	Submarine— <i>Kilo</i> Project 636M	200	200	Supersonic	INS/active
CH-SS-NX-13 ¹¹		Submarine— <i>Song, Yuan,</i> <i>Shang</i> , to be deployed on <i>Tang</i> ¹²	?	?	?	?

Sources

¹ This chart draws in part on data from Andrew S. Erickson, “China’s Modernization of Its Naval and Air Power Capabilities,” in *Strategic Asia 2012–13: China’s Military Modernization, Regional Stability, and U.S. Extended Deterrence*, ed. Ashley J. Tellis and Travis Tanner, 60–125 (Seattle: National Bureau for Asian Research, 2012).

² “C-701 (Kosar 1/3)/C-701AR (Zafar),” *Jane’s Naval Weapon Systems*, February 4, 2012.

³ The YJ-62 is a second-generation variant of the YJ-6 ASCM. “CSS-N-4 ‘Sardine’ (YJ-8/C-801); CSS-N-6 (YJ-83/C-802/Noor); YJ-62/C-602; YJ-82; CY-1,” *Jane’s Naval Weapon Systems*, August 13, 2012; Office of the Secretary of Defense (OSD), *Military and Security Developments Involving the People’s Republic of China 2012* (Washington, DC: Government Printing Office, 2012), 21 (hereafter referred to as *China Military Report* followed by the publication date); OSD, *China Military Report 2011*, 2; OSD, *China Military Report 2010*, 2; “China’s New Missile Deployment Being Monitored: Defense Minister,” *Central News Agency* (Taiwan), available at <www.globalsecurity.org/wmd/library/news/taiwan/2008/taiwan-081117-cna01.htm>.

⁴ The YJ-8 series ASCM has been in service on PLA Navy surface vessels for more than 20 years. “CSS-N-4 ‘Sardine’ (YJ-8/C-801); CSS-N-6 (YJ-83/C-802/Noor); YJ-62/C-602; YJ-82; CY-1,” *Jane’s Naval Weapon Systems*, August 13, 2012. OSD, *China Military Report 2011*, 4; OSD, *China Military Report 2010*, 3. See also “First Publicly-Released Photo of the YJ-82 Submarine-Launched Missile,” *China Defense Blog*, available at <<http://china-defense.blogspot.com/2010/11/first-public-release-photo-of-yj-82.html>>. The designators follow Christopher P. Carlson, “China’s Eagle Strike—Eight Anti-Ship Cruise Missiles, Parts 1, 2, and 3,” (Washington, DC: Defense Media Network, February 4, 2013).

⁵ “CSS-N-4 ‘Sardine’ (YJ-8/C-801); CSS-N-6 (YJ-83/C-802/Noor); YJ-62/C-602; YJ-82; CY-1,” *Jane’s Naval Weapon Systems*, August 13, 2012.

⁶ The YJ-83A is a third variant of the basic YJ-8 ASCM (export designation C-802A). See OSD, *China Military Report 2012*, 21; OSD, *China Military Report 2010*, 3. See also Bill Gertz, “Chinese Missile Has Twice the Range U.S. Anticipated,” *The Washington Times*, November 20, 2002, 3. The air-launched version is sometimes referred to as the YJ-83AK. *Jane’s* mistakenly refers to this variant as the C-803. Carlson argues that the PLA never deployed the 120 km C-802 variant and went straight to the 180 km variant, which he calls the YJ-83/C-802A. For specific performance parameters, see “C-801 (CSS-N-4 ‘Sardine’/YJ-1/-8/-81), C-802 (CSS-8 ‘Saccade’/YJ-2/-21/-22/-82/-85), and C-803 (YJ-3/-83/-88),” *Jane’s Strategic Weapon Systems*, February 7, 2012.

⁷ The YJ-91 is based on the Russian Kh-31P. See OSD, *China Military Report 2011*, 30; OSD, *China Military Report 2010*, 30. For performance parameters, see also “YingJi-91 (Kh-31P) Anti-Radiation Missile,” *China’s Defence Today*, available at <www.sinodefence.com/airforce/weapon/kh31.asp>. “YJ-91, KR-1 (Kh-31),” *Jane’s Air-Launched Weapons*, March 7, 2012.

⁸ “Kh-59M, Kh-59ME Ovod-M (AS-18 ‘Kazoo’),” *Jane’s Air-Launched Weapons*, March 7, 2012.

⁹ OSD, *China Military Report 2012*, 21; OSD, *China Military Report 2011*, 2; OSD, *China Military Report 2010*, 2.

¹⁰ Ibid.

¹¹ No Chinese designation has been identified yet and the missile still appears to be in development. See OSD, *China Military Report 2011*, 4; OSD, *China Military Report 2010*, 3.

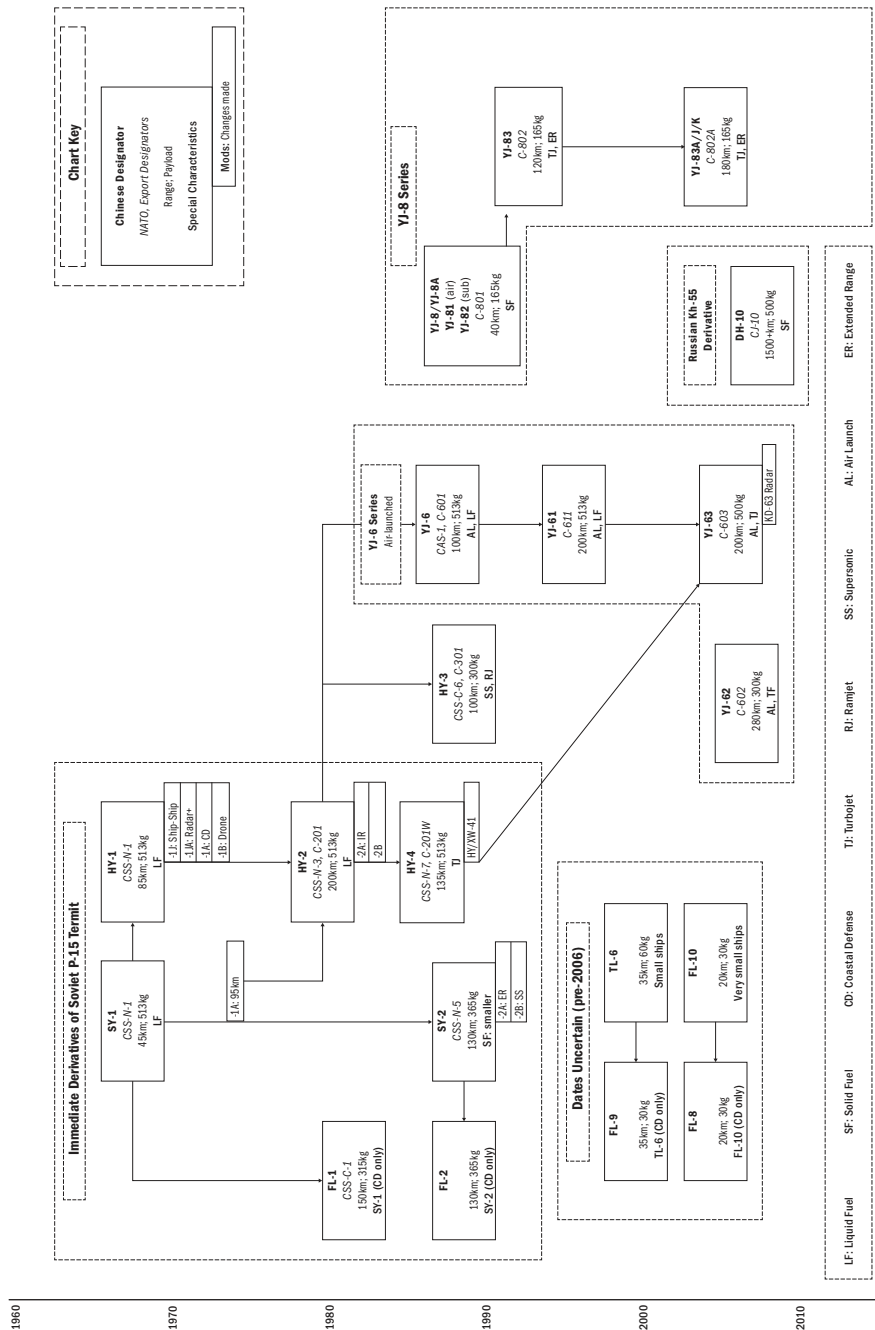
¹² OSD, *China Military Report 2011*, 4.

The PLAN still maintains an inventory of older and less capable SY-2 ASCMs, also known in the export market as Fei Long-2. Although only capable of ranges out to 50 km, the subsonic SY-2 carries a 365 kg time-delayed, semi-armor-piercing, high-explosive warhead capable of inflicting considerable damage against steel hulls and aluminum superstructures.³⁰ This offers a means of “forcing” Aegis ships to fire their inventory of standard missiles at these SY-2s and then having a second volley of “real” cruise missiles to follow once the Aegis standard missiles are expended.

Russia has also been contributing to China’s substantial indigenous missile inventory by selling advanced cruise missiles that have no operational Western equivalent. One of the more lethal PLAN ASCMs is the Russian import 3M-54E Klub ASCM (also known as the SS-N-27B Sizzler),³¹ noteworthy for its supersonic (Mach 3) second stage designed to defeat surface ship defenses. With INS/active guidance, this low-altitude sea-skimmer delivers a 200 kg warhead from a range of 200 km³² and can be launched from the PLAN’s eight newest *Kilo* Project 636M submarines.³³

China’s two *Sovremenny*-class Project 956 destroyers boast supersonic Raduga 3M80E Moskit (SS-N-22 “Sunburn”) ramjet-powered ASCMs, which were first delivered to China in April 2000.³⁴ This early variant of the SS-N-22 can deliver a 300 kg semi-armor piercing warhead guided by INS/active/passive guidance to a distance of up to 120 km³⁵ at only 7–20 m above the sea surface using a liquid ramjet engine and four solid boosters.³⁶ China’s more advanced Project 956EM *Sovremenny*-class destroyers (Hulls 138 and 139) carry an upgraded SS-N-22 variant, the 3M80MVE.³⁷ ONI and *Jane’s Defence Weekly* both cite a range of roughly 130 nm (240 km) for the 3M80MVE variant.³⁸ This missile was reportedly designed to defeat U.S. Navy Aegis/Standard RIM-67 air defense systems, and its terminal homing maneuvers and Mach 2.5 speed seriously complicate intercept.³⁹ Referring to Moskit/Kh-41 (the air-launched version of the Sunburn ASCM) and Yakhont (SS-N-26) ASCM, a foreign source claims that U.S. CSGs may not be capable of effectively using countermeasures to defend themselves against these missiles.⁴⁰

Figure 2.1. Genealogy of Cruise Missiles



China has also reportedly acquired both variants of the Russian Zvezda-Strela Corporation's greater-than Mach 2 Kh-31 (AS-17 "Krypton") 15–110 km-range supersonic, ramjet-powered missile.⁴¹ Following a joint program with Russia, China is apparently producing these ASCMs indigenously (initially under license) as the 15–120 km-range YJ-91 (based on the Kh-31P ARM variant).⁴² ARMs can target either land- or sea-based radars, depending on what characteristics (for example, pulse width and repetition rate) their seeker is programmed for. The Kh-31P/YJ-91 is reportedly capable of targeting a variety of maritime targets and could reach speeds of Mach 3.5 with an extended target range of 110 km, depending on cruise altitudes.⁴³ The PLAN's Sukhoi Su-30MK2 "Flanker" fighters, as well as its JH-7As and some PLAAF aircraft, are reportedly fitted with the Kh-31/YJ-91. Russia specifically designed the Kh-31P passive, high-speed antiradiation (as opposed to Kh-31A active radar) version to attack Western radar systems (for example, the U.S. Navy's SPY-1 and the U.S. Army's Patriot radar). This missile family employs an 87–90 kg HE blast/fragmentation warhead.

Russia's Raduga Corporation has produced advanced variants of the Kh-59 air-launched cruise missile for export including the Kh-59MK radar-guided antiship missile and the Kh-59MK2 LACM variant with an advanced terrain-matching navigation system that reportedly allows for 2–3 m CEP.⁴⁴ Open source information is sparse, but China has apparently acquired at least some of these missiles. Russia itself does not field the 45–115 km-range, inertial, radar-guided, and data-linked Kh-59MK variant that it helped to develop for the PLAN's Su-30MKK fighters and that it supplied them with.⁴⁵ Several years ago, a source of uncertain reliability claimed the PLAAF to be capable of launching the Kh-59ME TV-guided ASCM at ranges of 115 km in daylight and favorable weather conditions only.⁴⁶ *Jane's* claims the same range and credits the missile with a payload of 320 kg AP HE or 280 kg cluster.⁴⁷

Finally, China is developing an advanced submarine-launched ASCM that DOD refers to as the CH-SS-NX-13. No Chinese designation has been identified yet, and the missile still appears to be in development.⁴⁸ DOD states that it will be deployed on *Song*-, *Yuan*-, *Shang*-, and, when available, *Tang*-class submarines.⁴⁹

In addition to acquiring significant quantities of ASCMs, the PLAN has also developed models to determine the relationship "between the number of launching missiles and extent of target damages."⁵⁰ These models claim to yield extremely high probabilities of effectiveness against one or more surface targets.⁵¹ One may conclude that the PLAN not only seeks to mass ASCM firepower in the maritime environment to further deterrence, but also might intend to use it during saturation attacks against enemy surface ship formations.⁵² U.S. CSG forces, specifically Aegis fire control operators, ought to expect streaming attacks in the event of conflict with the PLAN.

The PLAN's ASCM inventory is thus diverse and numerous, particularly compared to what its potential foes might employ. U.S. forces today train with fewer ASCM variants, whose capabilities arguably pale in comparison to China's supersonic, sea-skimming missiles. Chinese platforms may be able to deliver lethal, multi-axis saturation strikes against a CSG at extended ranges. Hamstrung by limited ASCM load-outs, Aegis defense of the CSG may be disadvantaged vis-à-vis PLAN opponents. The examinations of PLAN ASCM delivery platforms in chapter 4, of employment doctrine and training in chapter 5, and of their potential utility in campaigns and missions in chapter 6 do not brighten the picture. To be sure, U.S. forces rely on weapons other than ASCMs for many of their offensive capabilities, making direct comparison of ASCM inventories a poor metric for potential performance in battle.⁵³ At the same time, however, the growing preponderance of Chinese ASCMs could well affect where and how U.S. CSGs are able to operate in the future.

Origin, Characteristics, and Capabilities of China's Land-attack Cruise Missiles

Several nations, China included, have examined the extensive use of LACMs by U.S. military forces over the last two decades with some envy. But rather than simply offering prestige of ownership, LACMs are becoming the long-range missile of choice for states seeking precision delivery of conventional payloads.¹ For a number of reasons, satellite navigation is a far greater enabler of precision attacks for cruise missiles than it is for ballistic missiles.² Due to their high accuracy, LACMs are uniquely capable of undertaking conventional attacks against certain classes of targets (point targets such as airfield bunkers and command and control facilities) that remain problematic for conventionally armed ballistic missiles.³ Equally important, due to LACMs' comparative affordability, their large-scale use in tandem with ballistic missiles augurs the prospect of penetrating even thick missile defenses should such defenses ever be deployed.⁴ As the 2011 DOD report documents, "The PLA continues to field air- and ground-launched LACMs, such as the YJ-63, KD-88, and DH-10 systems for stand-off, precision strikes."⁵ This chapter introduces the emergence of LACMs in the PLA by assessing sources of outside technical assistance that have contributed to China's current and prospective LACM programs. The characteristics and capabilities of known Chinese LACMs are also documented.

Table 3.1. PLA Land-attack Cruise Missiles¹

Type	Manufacturer	Launch Platform	Range (km)	Payload (kg)	Speed	Guidance
YJ-63/KD-63 ²	CASIC Third Academy/CHETA	Air (H-6H and H-6K bomber)	200	500	Subsonic	INS/(?)/Passive Electro-optical terminal guidance
DH-10/CJ-10 ³	CASIC Third Academy/CHETA	Ship, ground (3 canister on TELs) ⁴	1,500+	500	Subsonic	INS/Sat/TERCOM/Probable DSMAC for terminal guidance
KD-88 ⁵	CASIC Third Academy/CHETA	Air	180–200	165	Subsonic	Inertial; active terminal guidance
KD-20/YJ-100 ⁶	CASIC Third Academy/CHETA	Air	1,500–2,000	500	Subsonic	INS/Sat/TERCOM

Type	Manufacturer	Launch Platform	Range (km)	Payload (kg)	Speed	Guidance
Possible "DH-2000" ⁷	CASIC Third Academy/CHETA	Submarine	?	500	Subsonic	?
YJ-91/KR-1 (Kh-31P) ⁸	Zvezda-Strela, Russia; license-produced by China	Air (PLAAF/PLAN)	15–110	87–90 kg HE blast/fragmentation	Supersonic	Passive/Antiradiation
AS-13 "Kingbolt" (Kh-59MK) ⁹	Raduga, Russia	PLAAF Su-30MKK	115	320 kg AP HE or 280 kg cluster	Subsonic	Inertial and TV/electro-optical

Sources

¹ This chart draws in part on data from Erickson, 60–125.

² OSD, *China Military Report 2011*, 30; OSD, *China Military Report 2010*, 31; *Ballistic and Cruise Missile Threat* (Wright-Patterson Air Force Base, OH: National Air and Space Intelligence Center, April 2009); and "KongDi-63 Air-Launched Land-Attack Cruise Missile," *China's Defence Today*, available at <www.sinodefence.com/airforce/weapon/kd63.asp>.

³ OSD, *China Military Report 2011*, 2; OSD, *China Military Report 2010*, 31.

⁴ Currently testing on *Dahua* (Hull 892).

⁵ OSD, *China Military Report 2012*, 21, 42; The KD-88 is a derivative of the YJ-83, roughly comparable to the U.S. land-attack variant of Harpoon. OSD, *China Military Report 2011*, 30; OSD, *China Military Report 2010*, 31. See also "KD-88," *China's Defence Today*, available at <www.sinodefence.com/airforce/weapon/kd88.asp>.

⁶ Chen Wen-cheng [陳文政], "Defense Turning Back" [國防, 向後轉], *New Century Foundation Think Tank Quarterly* [新世紀智庫論壇] 46 (June 30, 2009), 14–17, available at <www.taiwannccf.org.tw/ttforum/46/46-04.pdf>. Chen Wen-cheng is former senior advisor for Taiwan's National Security Council. The YJ-100 designation for the air-launched variant of the DH-10 has also been included in MND briefings.

⁷ Tseng Fusheng [曾復生], "America Considers Communist China's 'Counter-Intervention Strategy'" [美國因應中共(反介入戰略)的思維], National Policy Foundation National Security Brief, June 17, 2010, available at <www.npf.org.tw/post/3/7677>.

⁸ The YJ-91 is based on the Russian Kh-31P. See OSD, *China Military Report 2011*, 30; OSD, *China Military Report 2010*, 30. For performance parameters, see also "YingJi-91 (Kh-31P) Anti-Radiation Missile," *China's Defence Today*, available at <www.sinodefence.com/airforce/weapon/kh31.asp>; "YJ-91, KR-1 (Kh-31)," *Jane's Air-Launched Weapons*, March 7, 2012.

⁹ "Kh-59M, Kh-59ME Ovod-M (AS-18 'Kazoo')," *Jane's Air-Launched Weapons*, March 7, 2012.

However limited the knowledge base about China's LACMs may be, one thing is clear: China has depended heavily on Russian exports and specialized technical skills in enabling and improving its growing arsenal of LACMs. The governments of Israel, Ukraine, and Belarus have also contributed to China's military industrial development through arms and technology transfers.⁶ As chapter 1 explains, the engineering base supporting the development of complex military systems was devastated during the Great Leap Forward and the Cultural Revolution. Cruise missile efforts were better protected

than aircraft development but not as well as ballistic missile programs. To be sure, China's current quest to build a first-rate defense industrial infrastructure is benefiting materially from numerous foreign joint ventures in the civilian sector and from the significant number of Chinese students who are matriculating abroad in the best engineering universities, as well as through military and civilian industrial espionage.⁷ Nevertheless, regarding LACM development, Russia has played the most significant role.

Historical happenstance has amplified Russia's support of China's cruise missile ambitions. Beijing's technical requirements aligned well with the needs of Moscow's defense sector for hard currency in the early 1990s in the aftermath of the Soviet Union's demise. China's defense technology needs were particularly compelling when the United States terminated arms sales after the Tiananmen Square crackdown in 1989. More broadly, in the area of their defense relationship, in 1993 Russia and China signed a 5-year agreement to cooperate in military technology including exchanging skilled technical specialists.⁸ According to Russia scholar Stephen Blank, China sought Russian approval to recruit at least one cruise missile R&D team.⁹ One Taiwan source reported that China succeeded in recruiting between 1,500 and 2,000 laid-off Russian scientists and engineers and moved them to a factory called Xinxin in Shanghai where they joined Chinese technicians at work on "imitated versions of the Kh-55," a 3,000 km-range LACM capable of delivering a nuclear payload.¹⁰

Other than building an LACM from scratch, the most direct route to developing one is to convert an ASCM into a more complex land-attack system. The stiffest challenge here, but by no means insurmountable in China's case, lies in developing a suitable land-attack navigation system that could enable the missile to fly safely over Earth's varied land terrain.¹¹ With roughly 75,000 ASCMs in over 70 nations, 40 of which are in the developing world, China can choose from an ample supply.¹² It is no surprise that China has investigated this route to developing cruise missiles for attack over land. It is also no surprise that China has turned to its own HY-4 (Hai Ying-4) ASCM, named Silkworm by Western intelligence,¹³ which has a range of about 100 km, as a test bed for a far more potent and capable LACM called the Ying Ji-63 (YJ-63), an air-launched LACM developed by CASIC's Third Academy and carried by the H-6H and H-6K bombers. This missile possesses two to five times the range of its progenitor, the Silkworm, and a land-attack capability.¹⁴ Yet the roots of the Chinese Silkworm are hardly indigenous. Rather, they extend back to Soviet and, more recently, Russian sources that have proved critical in supporting China's LACM ambitions.

The Silkworm's ancestral roots originated in the Soviet-era Shtorm coastal defense missile, initiated in the mid to late 1940s, which begat the Soviet Union's first true ASCM, the P-15 (Styx).¹⁵ The P-15/SS-N-2A that became operational in Soviet naval units in 1960 carried a 450 kg warhead only 40 km. By the late 1960s, Soviet designers had improved

subsequent variants of the Styx ASCM, the P-15M/SS-N-2C, that permitted the missile to achieve a range of 80 km while carrying a payload of slightly over 500 kg. Perhaps the most memorable use of the Styx occurred during the 1967 Arab-Israeli war when the Egyptian navy used it to sink the Israeli destroyer *Eilat*.

In 1958 China acquired Styx missiles and the technological wherewithal to produce them from the Soviet Union; two years later it commenced licensed production of what was essentially a copy of the Styx ASCM. Called the Shang You-1 (SY-1, or Scrubbrush), the missile became the fundamental design for a series of ASCMs (HY-1, HY-2, and HY-4) that dominated Chinese naval ASCM deployments through the 1980s. The HY-4 and YJ-6 became central test beds for future LACM explorations.¹⁶

What makes the Silkworm an appealing candidate for LACM conversion compared with other ASCMs? The sheer size of the Silkworm ASCM is the most important factor. Styx-derivative ASCMs have a launch weight of 2,500 to 3,000 kg, largely due to their heavy liquid-propellant engines and bulky radars. By contrast, a modern Tomahawk LACM weighs roughly 1,400 kg. Yet in terms of conversion, size (or volume) is a virtue, because conversion entails removing the existing engine and sea-based guidance system and replacing them with a smaller turbojet engine and a much smaller inertial guidance system supported by a lighter terminal guidance system.¹⁷ Such an exchange would free up ample space within the missile's body for additional fuel to increase the converted missile's range substantially. This would not be the case with more modern ASCM designs like the French Exocet, which employs a smaller airframe densely packed with integrated electronics and software, leaving virtually no space for adding fuel, changing engines, or rearranging avionics. In the case of the conversion of the U.S. Harpoon ASCM into a land-attack missile (called the Standoff Land Attack Missile, or SLAM), the land-attack system gained only a few kilometers of additional range as a consequence.¹⁸ By contrast, modifying Silkworm ASCMs is inherently easier and requires less engineering skill. Structural modifications of the airframe, for example, require installing bulkheads or partitions between compartments and riveting simply shaped aluminum plates to extend the airframe's length.¹⁹

Other nations besides China are working to convert Silkworm ASCMs into land-attack variants. Iraq worked diligently, before the United States invaded that country in 2003, on two efforts to extend the range of its China-supplied Silkworm missiles. The first and less-ambitious effort, called Al Faw, seems to have commenced in the early 1990s and was disclosed to UN inspectors in 1996. Work resumed after inspectors left Iraq in late 1998. By that time Iraqi engineers had extended the range from 100 to 150 km. Such extended-range Silkworms likely include the five fired by Iraq during the 2003 U.S.-led invasion.²⁰ On a more ambitious scale, Iraq undertook—with Saddam Hussein's personal support—a program to extend the range of the Silkworm to 1,000 km (about

two-thirds the range of a Tomahawk) while converting the missile to navigate over land. The indigenous Jinin project was conceived in November 2001 and launched in June 2002 with hopes that the project would be completed within a 3- to 5-year period. In anticipation of UN inspectors returning to Iraq in December 2002, Iraq decided to shelve the program out of fear of being caught in violation of UN resolutions proscribing missiles with ranges exceeding 150 km.²¹

Iran reportedly is also following the same path to convert the Silkworm into a longer-range LACM. According to a NATO report, Iran is upgrading around 300 HY-2 Silkworms; however, instead of using helicopter turbine engines²² as Iraq did, Iranian engineers are outfitting them with turbojet engines and new land navigation systems.²³ Where Iran acquired the necessary turbojet engines is uncertain, but Chinese entities are surely candidates as these companies have been implicated in selling Iran not only the HY-1, HY-2, and C-801 ASCMs but also the C-802 and possibly the HY-4, which comes equipped with a turbojet engine.²⁴ The HY-4 is the only missile in China's HY series that comes with the WP-11 turbojet engine—a reverse-engineered Chinese version of the U.S. Teledyne-Ryan J69-T-41A that powered the Vietnam-era Firebee reconnaissance drone.²⁵ Alternatively, Iran may have acquired suitable gas-turbine engines through illegal means.²⁶

The YJ-63 Air-launched Land-attack Cruise Missile

Developed by CASIC's Third Academy, the YJ-63 LACM was designed to provide standoff air-launched precision strike capabilities for PLAAF's H-6H bomber (copied from the Russian Tu-16 Badger).²⁷ Some sources claim that the YJ-63 was developed from the HY-4 coast-to-ship cruise missile. Reportedly deployed in 2004–2005, the YJ-63 uses an inertial guidance system and an electro-optical television system for the terminal attack phase, achieving a circular error probable (CEP)²⁸ of 10–15 m while carrying a payload of 500 kg.²⁹ The YJ-63 is also capable of man-in-the-loop guidance with target imagery from the electro-optical seeker sent back to the launch aircraft via the H-6's datalink antenna, which is mounted in an underbelly fairing behind the bomb bay doors.³⁰

The YJ-63's reported range varies from 200 to 500 km.³¹ One early report suggested a 500 km range for the YJ-63, but more recent Chinese reports cite a 200 km range. The YJ-63 is powered by an FW41-B turbojet engine, which should propel the missile at a speed of roughly Mach 0.9.³²

The YJ-63's lineage from the Silkworm missile is most evident by viewing photographs. Looking much like the HY-2, the turbojet-equipped HY-4, or the air-to-ground YJ-6 (C-601), the YJ-63 has a large round body with a correspondingly round nose. Its turbojet engine inlet, like the HY-4, is located under the body just behind the large delta wings. The YJ-63's tail control surfaces are arranged in an X.³³ The dimensions of

the YJ-63 appear similar to the YJ-61, with a length just under 7.5 m, its diameter about three-quarters of a meter, and its wingspan 2.4 m. The overall weight is estimated to be around 2,500 kg.³⁴

Dong Hai-10 (DH-10)/Chang Jian-10 (CJ-10) Long-range Land-attack Cruise Missile

The Intelligence Community's challenge of monitoring LACM development programs is nowhere more apparent than with the sudden emergence of China's DH-10 (东海-10)/CJ-10 (长剑-10),³⁵ which was reportedly first tested in the fall of 2004. Other reporting indicates integrated flight tests as early as 2003 (see discussion below). According to the *Washington Times*, a 2005 report delivered to the Director of National Intelligence concluded that the Intelligence Community had missed more than a dozen Chinese military developments, including a new long-range cruise missile.³⁶ In 2009, the U.S. Air Force National Air and Space Intelligence Center (NASIC) released the latest version of its aperiodic compendium of foreign ballistic and cruise missile programs.³⁷ It included two Chinese LACMs: the air-launched YJ-63 (listed with undetermined operational status and range) and the DH-10 (listed with undetermined range, operational capability, and launch mode). The reported 2004 DH-10 test suggests that this missile is likely the reported "new long-range cruise missile." The DH-10 is a ground-launched, second-generation LACM that has a range of 1,500+ km and employs INS and TERCOM for guidance, as well as probably DSMAC for terminal guidance.³⁸ The 2010 DOD report indicates that 200–500 missiles are already available for use on 45–55 ground-based launchers.³⁹ This missile is likely guided to its target by an integrated inertial/GPS reference system supported by terrain contour mapping and digital scene matching for terminal homing, the combination of which should provide a CEP of 10 m.⁴⁰ From the general appearance of the DH-10 in Internet pictures, the missile's lineage seems related to the Russian Kh-55, although it has only half of the range.

Based on analysis of Chinese industry reporting, the chief designer for the DH-10 was apparently the Third Academy Third Design Department's Liu Yongcai [刘永才]. Liu's preliminary design research probably began in 1992. Then-CASIC Deputy Director Xue Li [薛利] oversaw testing in 2003.⁴¹ One of Xue's senior colleagues, Ma Henghua [马恒华], was a chief designer of a major ASCM system.⁴²

While DOD's 2011 report refers to the DH-10 as "ground-launched,"⁴³ a ship-launched variant has appeared in Internet photos on a PLAN *Dahua*-class weapons test ship (Hull 892), albeit in a two-canister configuration vice the ground-launched standard three-canister configuration.⁴⁴ Moreover, development of an air-launched variant may be underway. The report adds that "China is upgrading its B-6 [H-6] bomber fleet (originally adapted from the Soviet Tu-16) with a new, longer-range variant that will be

armed with a new long-range cruise missile.”⁴⁵ The report indicates that the H-6 variant armed with this air-launched LACM will extend the reach of China’s regional precision strike capabilities out to 3,300 km, which is sufficient to reach Guam.⁴⁶ Figure 3.1 (taken from the report) superimposes the range of the DH-10, China’s new air-launched LACM, and other missiles on a map of China and the surrounding region.

Ground-launching requires an additional small rocket booster to get the missile off the launcher whereupon the engine is ignited until the missile flies aerodynamically. Air-launching does not require a booster rocket, but only a release mechanism to drop the missile away from the aircraft before the engine takes over. The Chinese have air-launching capabilities as evidenced by the YJ-63 LACM, which is carried by the

Figure 3.1. China’s Conventional Antiaccess/Area-denial (A2/AD) or “Counter-intervention” Capabilities



H-6 bomber. Weight is another matter. A large bomber can launch the DH-10, but it is unlikely that smaller tactical aircraft could launch it. Internet photos show H-6K Badger aircraft with six CJ-10 LACMs.⁴⁷ The bottom line is that a DH-10 ALCM is conceivable, but DOD officials cannot confirm its outfitting on a particular aircraft. The fact that NASIC says “undetermined” supports the possibility of an ALCM option for the DH-10.

The DH-10’s emergence raises the question of the current status of the Hong Niao series of Chinese LACMs thought to be under development with Russian assistance in the early 1990s. *Jane’s* reported in 2000 that China was “racing ahead” with at least three new LACM programs, though the report admits these developments were “not confirmed officially.”⁴⁸ The *Jane’s* article describes Chinese dependence on the Silkworm family of AS-CMs, yet the first missile to emerge from the Chinese program, the Hong Niao-1 (HN-1), appeared similar to the Russian Kh-55. With a range of 600 km, the HN-1 was supposed to possess the standard set of LACM characteristics, including midcourse inertial guidance aided by GPS updates, a radar altimeter, and a terrain comparison electro-optical television system for improving the missile’s terminal accuracy.⁴⁹ *Jane’s* also speculated that China had benefited from exploiting one or more of the several U.S. Tomahawk cruise missiles recovered by Pakistan during the 1990s.⁵⁰ Two additional Chinese cruise missiles allegedly sprang from this development effort: the HN-2, in 1996, with a range of 1,500 to 2,000 km, and the HN-3, which in 2000 was described as still under development. Interestingly, when *Jane’s* reported the DH-10’s test launch in October 2004, the article made no mention of any of the HN-series LACMs.⁵¹ The seeming confusion between the HN-series—called the “imitated versions of the Kh-55” or the “Russian copy-series” by Taiwan analysts⁵²—and the DH-10 was apparently settled with NASIC’s 2006 publication, which averred the existence of two Chinese LACM programs, the YJ-63 and the DH-10.

Stories about the Hong Niao series may have emanated from Russian attempts during the early 1990s, when Russian technicians were reportedly working closely with the Chinese, to exploit their Kh-55 missile for export purposes. As their military design bureaus were struggling to remain solvent, Russian military and export officials initiated an international air show at Moscow’s Zhukovsky airfield in August 1992. On display was an “Airborne Tactical Missile” (ATM), or at least a sketch of it appeared in a sales brochure. The missile was described as having a length of 6.04 m, a diameter of 0.514 m, a wingspan of 3.1 m, and a launch weight of 1,250 kg—strikingly close to the characteristics of the Kh-55SM, an upgraded version of the original Kh-55 air-launched cruise missile.⁵³ The sketch revealed the missile’s distinctive positioning of the engine under the fuselage, indicating its parentage, the Raduga Design Bureau’s Kh-55 strategic-range nuclear-capable LACM.⁵⁴ But the ATM was listed as having only a 500–600 km range instead of the Kh-55’s 3,000 km. No doubt, Russian export officials insisted that the range should make the missile’s export prospects consistent with Russia’s obligations under the 1979 U.S.-Soviet Strategic

Arms Limitation Treaty (SALT II). This treaty never entered into force, but both parties voluntarily counted any aircraft carrying cruise missiles with a range exceeding 600 km as “strategic” and, therefore, limited their numbers in accord with SALT II provisions.

The 1987 MTCR may also have shaped Russian behavior about exploiting the Kh-55 design for export purposes. At the 1992 Moscow Air Show, Russia was neither a member of the MTCR nor adhered even informally to the regime’s principles. Hence Moscow had no obligation to honor the regime’s range threshold of 300 km. But circumstances changed in July 1993 when Russia agreed to adhere to the MTCR’s guidelines as of November 1, 1993. (Russia became a full member of the MTCR in October 1995.) Conceivably in anticipation of these new obligations, Russian export and defense officials displayed a new “tactical” version of the Kh-55 for export at the February 1993 Imagery Data Exploitation System Defense Exhibition in Abu Dhabi. Instead of ATM, the Kh-55 derivative was called the Kh-65SE with a declared range of 280 km, making it appear MTCR-compliant.⁵⁵

All this suggests that the HN-series is apocryphal and that the true derivative of the Russian Kh-55 and its many shorter-range offspring is the DH-10.

The story of the HN-series of Chinese LACMs underscores the challenges inherent in developing any sophisticated cruise missile that must navigate over long distances and diverse terrain conditions and hit its intended target with great accuracy.⁵⁶ (China’s cruise missile guidance options will be examined in detail below.) An equally critical and in many ways more challenging endeavor is the development of a highly efficient turbofan engine to permit Chinese LACMs to reach beyond 1,000 km. Clearly, the DH-10’s reported range of more than 1,500 km suggests that China has done so. How it may have accomplished this goal is suggested by the multipronged strategy to acquire specialized know-how through joint commercial ventures, purloin relevant technology, or complete systems through illegal means.

The end of the Cold War ushered in a liberalization of export controls on dual-use products and technologies, and with this more open market China acquired production processes for U.S. jet engines. One example occurred in 1996 when the Chengdu Engine Company established a joint venture with Pratt & Whitney Canada, a subsidiary of U.S.-based United Technologies, to manufacture aviation parts. Chengdu not only manufactures components used in Boeing commercial aircraft but also components for the PLAAF’s WP-13 turbojet engine that powers the F-8 fighter.⁵⁷ In 2003, a joint venture was established between General Electric and Shenyang Liming Aero-Engine Corporation to coproduce the CF034-10A jet engine for one of China’s regional jets. But even more relevant to its cruise missile ambitions, around the same time China acquired Russian expertise that assisted development of the WS-10A turbofan engine for China’s J-10 and the J-11 version of the coproduced Su-27. The engine, flight-tested in 2002 but not yet widely deployed, is envisioned to outperform the Russian AL-31 engine that powers the

Su-27, though this assumption remains unproved in practice.⁵⁸ The standing challenge for China is to produce a sufficiently compact but highly fuel-efficient turbofan engine like the Kh-55's R-95-300.

As for purloining foreign technology relevant to its LACM programs, in 2000 China received six Kh-55 strategic-range LACMs. In February 2005, a Ukrainian parliamentary official disclosed that Ukrainian and Russian arms dealers including the head of Ukrspetsexport, Ukraine's export agency, had been charged with conspiracy to sell 12 to 20 Ukrainian Kh-55 cruise missiles to China in 2000 and to Iran in 2001.⁵⁹ Reverse engineering, even with the difficulties in application to a complex system like a turbofan engine, should have proved valuable already. China could also have gained valuable knowledge when it acquired and analyzed recovered Tomahawk cruise missiles from Pakistan. The value of such access would depend on the amount of damage the missiles sustained after crashing. We cannot know to what degree Chinese intelligence organizations have obtained technology or components related to foreign LACM programs, but we know through their failures that they are hard at work in such endeavors. In 2005, U.S. Customs Service agents, in a sting operation attempting to stop the export of military items to the People's Republic of China, apprehended Ko-Suen "Bill" Moo, a citizen of Taiwan who worked for American defense contractor Lockheed Martin in Taiwan. Federal prosecutors charged Moo and a French national, who was also indicted but remains at large, with attempting to purchase an F-16 jet engine, cruise missiles, and air-to-air missiles for China. Moo provided an undercover Customs agent with documents showing specific Chinese interest in acquiring the U.S. AGM-129 "Advanced Cruise Missile" LACM, which is capable of carrying a nuclear warhead up to 3,700 km. The AGM-129 was developed in the 1980s to penetrate thick Soviet air defenses using advanced stealth features. The missile was supposed to remain in the U.S. inventory until 2020 but is being retired early as part of U.S. nuclear reductions required under the Moscow Treaty of 2002. Moo had deposited \$3.9 million in a Swiss bank account to purchase weapons and an additional \$140,000 via a wire transfer to cover shipping fees. He pleaded guilty in 2006 to acting as a covert agent for the Chinese government.⁶⁰ In 2011, he was deported to Taiwan and "disappeared."⁶¹

No doubt China's apparent interest in the AGM-129 matched its need to improve the penetration capabilities of its own LACMs. Based on China's reported R&D work, Chinese engineers appreciate that the application of radar and infrared reduction treatment to LACMs can reduce a missile's radar signature by one and a half orders of magnitude.⁶² To this end, the Beijing Institute of Aviation Materials has reportedly developed paint-based radar absorbing materials, neoprene tile radar absorbing coatings, and form-based radar absorbing coating, among others.⁶³

Chinese covert access to cruise missile technologies appears to continue. According to the 2011 DOD report, "In August 2010, Noshir Gowadia was convicted of providing the

PRC with classified U.S. defense technology. Gowadia assisted the PRC in developing a low-signature cruise missile exhaust system capable of rendering a cruise missile resistant to detection by infrared missiles.⁶⁴

Other Chinese LACMs

A derivative of the YJ-83, the KD-88 is roughly comparable to the U.S. land-attack variant of Harpoon. Deployed in the PLAAF, this subsonic air-launched LACM has a range of 180–200 km, a payload of 165 kg, and inertial active guidance.⁶⁵ China has also reportedly deployed another subsonic air-launched LACM, the YJ-100, which has a 1,500–2,000 km range, a 500 kg payload, and INS/TERCOM guidance.⁶⁶ This may be an air-launched version of the DH-10/CJ-10.

The addition of LACMs capable of being launched from submarines or surface ships would significantly enhance China's emerging arsenal of cruise missiles. Here again, Russia could possibly advance Chinese capabilities quickly through sales of derivatives of previously long-range cruise missiles developed during the Cold War. In 1984 the Novator Design Bureau delivered the Soviet Union's first submarine-launched cruise missile, the 3M-10 (called the SS-N-21 in the West), which was capable of delivering a nuclear payload to a range of 3,000 km. Borrowing from the 3M-10's technology, Novator fabricated a purportedly MTCR-compliant (not to exceed 300 km range and 500 kg payload) LACM called the 3M-14E (the "E" denoting export), capable of being launched from a 533 millimeter (mm) submarine torpedo tube just like its progenitor, the 3M-10. But the 3M-14 delivers a 400 kg conventional payload to 300 km. Reports circulating in 2005 suggested that the purchase of eight *Kilo*-class Project 636M diesel-electric submarines from Russia included 3M-14Es.⁶⁷ A 2008 British parliamentary report indicated that China's *Kilo*-class submarines "could possibly be equipped with the 3M-14[E]."⁶⁸ Still, no reliable open source has confirmed the acquisition of the 3M-14E cruise missile.

Rumors have also surfaced in Taiwan sources of a possible subsonic "DH-2000" submarine-launched LACM with a 500 kg payload.⁶⁹

PLA UAVs and Drones⁷⁰

Having observed the U.S. military's extensive use of UAVs and drones in recent years, China is purchasing foreign models, transforming former piloted aircraft into unmanned combat aerial vehicles (UCAVs), and developing indigenous variants. UAV development appears to be proceeding with growing interest. At least 25 UAV models/prototypes from a variety of companies and research institutes/universities were displayed at Airshow China in Zhuhai in 2010, as opposed to 12 in 2008.⁷¹ According to ONI, "China is devel-

oping UAVs that have the potential to bring multi-mission capabilities to the maritime environment. In recent years, Chinese officials have openly touted the benefits of UAVs, such as low manufacturing costs, lack of personnel casualties, and inherent 'stealthlike' characteristics.⁷² For example, in 2011 the PLAN was reportedly observed using a TKJ-226 UAV (a communications relay version of the ASN-209) during an exercise in the South China Sea.⁷³

China's growing arsenal of UAVs offers improved reconnaissance and strike capabilities. It provides the PLA with options to penetrate Taiwan's defenses by shutting down its early warning and missile defense radars. Antiradiation drones or UAVs such as Israel's Harpy, which has been sold to China, possess stand-off ranges of 400 km or more and, with the enormous challenges Taiwan faces in defending simultaneously against Chinese ballistic and cruise missile threats, could make Taiwan's investment in missile defenses increasingly problematic.⁷⁴

Combat UAVs

Chinese UAVs with both surveillance and combat capabilities include the imported Harpy, a possible UCAV based on WZ-2000 reconnaissance model the Winglong/Pterodactyl 1 MALE UAV, the CH-3/PW-3 UCAV, the WJ-600/A MALE UAV, the ASN-209 Tactical UAV System, and the ASN-229A Reconnaissance and Precise Attack UAV.

Beijing obtained 100 Harpy antiradar drones from Israel in 2001.⁷⁵ These small, stealthy, autonomous flying bombs could play a potent role in a Taiwan contingency by destroying air defense radars. Propeller-driven, Harpys can loiter over a battlefield for up to 2 hours at ranges of 400 km from their launch sites. Once it detects a radar emission it has been programmed to attack, a Harpy promptly dives directly at that radar antenna and destroys it with a 32 kg explosive warhead. Targeted radars risk attack unless they remain turned off. According to Israeli sources, China may have reverse-engineered and indigenously produced additional Harpys.⁷⁶ The late 2004/early 2005 diplomatic furor between the United States and Israel over Israeli attempts to maintain and upgrade China's Harpys underscores the perceived utility of these weapons.⁷⁷

Unveiled in 2008 and likely based on the WZ-2000, a turboprop-powered UCAV similar in size to U.S. Predator-2 is being developed by Guizhou Aircraft Industry Corporation (GAIO) and Luoyang Optoelectro Technology Development Center (LOEC), the latter of which is fashioning a wide range of UAV weapons. Home to LOEC and AVIC's 613 Research Institute, Luoyang is China's military electro-optical sensor payloads center. The UCAV is reported to be armed with TY-90 air-to-air missiles (AAM) and AR-1 air-to-surface missiles (ASM).

The Winglong/Pterodactyl 1 MALE UAV is perhaps China's most-established UAV. Launched in May 2005, a UAV prototype was displayed at the 2008 Zhuhai Airshow, tested in 2008, validated with weapons beginning in 2009, cleared for export in June 2009, and redesigned significantly by 2010. Reportedly equipped with a 100-hp (horsepower) reciprocating engine, it has a 1,150 kg maximum take-off weight, a 200 kg payload, a 5,000 m operational altitude, and 20-hour endurance. It is equipped with a Ku-band sitcom antenna and armed with 2 HJ-10 (ADK-10) 50 kg laser-guided antitank missiles.

CASC's CH-3/PW-3 UCAV is currently in production and has been approved for export. The CH-3/PW-3, unveiled at the 2008 Zhuhai Airshow, is propeller-driven with a reciprocating piston engine that allows for a service ceiling of 5 km, 12-hour endurance, and 2,398 km maximum range. It possesses an S-band data link and 60 kg maximum payload. This UCAV is armed with 2 AR-1 semiactive laser-guided missiles and is optimized for low-to-medium close air support missions. The Chinese press reported in October 2009 that the CH-3/PW-3 has received an export order; it may serve as an export competitor of the Winglong/Pterodactyl 1.⁷⁸

The WJ-600/A MALE UAV has both turbojet (-600) and turboprop (-600A) versions. This jet-engined versatility distinguishes it from most other Chinese UAVs. Developed and produced by CASIC, it was first displayed at the 2010 Zhuhai Airshow and has subsequently been delivered to the PLAAF. Optical reconnaissance, synthetic aperture radar (SAR), electronic warfare, and target simulation payload options appear to optimize the WJ-600/A for high-speed intelligence, surveillance, and reconnaissance (ISR) and strike. Armed with 2 KD-2/TB1 ASMs and a ZD1 laser-guided bomb, the WJ-600/A has an estimated service ceiling of 10 km, a maximum speed of 600 km/h, and an endurance of 6 hours.⁷⁹

The ASN series, developed by Xi'an Northwestern Polytechnical University ASN Technology Group Company, includes more than a dozen designs, at least seven of which have been approved and some of which have been produced in small numbers. Leading Xi'an's series of tactical UAVs, and one of the few that is armed, the ASN-209 Tactical UAV System is a medium-altitude, medium-endurance (MAME) UAV. Marketed by CATIC, the ASN-209 has both civil and military applications. It can be outfitted with a variety of military payloads weighing up to 50 kg including SAR, electro-optical EO sensors, multifunction, ground moving target indication (GMTI), electronic intelligence (ELINT), electronic warfare (EW), ground target designation (GTD), and communications relay payloads. Propeller-driven and powered by a piston engine, the 320 kg UAV has a maximum speed of 180 km/h, a cruising speed of 141 km/h, a service ceiling of 5 km, an operational radius of 100 km, and 10-hour maximum endurance. Guidance and control are likely autonomous. It engages in parachute recovery and skid landing.⁸⁰

Xi'an's ASN-229A Reconnaissance and Precise Attack UAV, which may have entered into service in 2011, is powered by a single-piston engine and possesses a satellite communications (SATCOM) datalink. Tactical and reconnaissance payloads include a combined EO/IR/laser rangefinder/designator. Armed with a mini precision-guided weapon, the ASN-229A has a maximum speed of 180 km/h, an operating altitude of 8 km, a service ceiling of 10 km, an operational radius of nearly 2,000 km, and 20-hour maximum endurance.⁸¹

Reconnaissance and Target Testing UAVs

China's reconnaissance UAVs include the WZ-9 (WZ-2000) MALE UAV; Changhong 1/WZ-5 and /WZ-5A variants; the Xianglong/Soar Dragon high altitude, long endurance (HALE) UAV; and the ASN-series tactical reconnaissance UAVs. China is also developing vertical take-off/landing UAVs (VTUAV) including the X200, reportedly sold to a military customer, and the X200S, a maritime variant that may be fielded in 2013.⁸²

GAIC's new generation WZ-9 (WZ-2000) MALE UAV was unveiled at the 2000 Zhuhai Airshow; an updated version was revealed in 2002. Powered by twin turbojets and visually similar to General Atomics' Predator, this UAV may be a technology demonstrator; flight testing has apparently been conducted.⁸³

The Beijing University of Aeronautics and Astronautics (BUAA) Changhong 1/WZ-5/A is a HALE conventional UAV with a range of 2,400 km. Its airframe is based largely on the U.S. Northrop Grumman BQM-34A Firebee aerial target, and its overall design follows the Teledyne Ryan Model 147H (AQM-34N) shot down over China pre-1972. Development began in 1969, and it entered service for training and tactical reconnaissance in 1981. Powered by the 8.35 kN BUAA WP11 turbojet, the 1,700 kg (65 kg payload) UAV was updated in the late-1990s with a digital flight control/management system and an inertial navigation system with embedded GPS. Air-launched using the Y-8E aircraft, Changhong 1 is programmed to follow a preprogrammed flight plan and is recovered in midair during parachute descent. Its maximum speed is 800 km/h, operating altitude is 17.5 km, range is 2,500 km, and endurance is 3 hours. Production has ended, but it remains in service in the PLA and in PRC civil agencies. China offered it for export beginning in 2000, but no sales have been reported.⁸⁴

BUAA's BZK-005 heavy UAV apparently began development in 2005 and was first seen in a video at the 2006 Zhuhai Airshow; its present status is uncertain. Propeller-driven with a piston engine, the 1,250 kg UAV's 150 kg payload includes electro-optical/infrared capabilities with real-time data transmission and, apparently, a SATCOM antenna. Its estimated maximum speed is 219 km/h with 40-hour maximum endurance and an 8,000 m service ceiling.⁸⁵

Xi'an's extensive ASN series is primarily composed of unarmed reconnaissance UAVs. The short-range multirole ASN-206, capable of ISR and electronic warfare and countermeasures with a variety of optical and laser instruments and imagery downlink, is in service in the PLA. Launched via booster rocket and recovered by parachute, the 222 kg UAV is powered by a 7.3 kW SAEC (Zhuzhou) HS-700, four-cylinder, two-stroke engine and has a maximum speed of 209 km/h, service ceiling of 5 km, range of 150 km, and maximum endurance of 8 hours.⁸⁶ The improved 250–480 kg ASN-207 medium-range version is market-ready and possibly already in PLA service. If operating in tandem with a similar UAV performing a relay function, the ASN-206 has a maximum speed of 180 km/h, service ceiling of 8 km, range of 600 km, and maximum endurance of 16 hours.⁸⁷ A variety of smaller variants round out Xi'an's ASN series. The ASN-104 and 105B (extended range) light UAVs, both of which are in service in the PLA, are powered by single Xi'an four-cylinder two-stroke engines and offer up to 2 hours of real-time reconnaissance.⁸⁸ The ASN-16 is a close-range tactical mini-UAV,⁸⁹ while the ASN-213 appears to be a technology demonstrator.⁹⁰

Other surveillance UAVs include the Nanjing Research Institute on Simulation Technique's W-30 and W-50 as well as its PW-1 and PW-2, each of which is propelled by two-stroke engines and carries a video camera with real-time telemetry and imagery downlink. While the status of the PW-2 is unknown, the first three are reportedly deployed in the PLA.⁹¹

Chinese target drones include the TianJian-1 cruise missile simulation version (which reportedly entered service in 2005); Sha'anxi's Chang Kong-1, -1A, -1B, -1C, and -1E versions (of the Soviet Lavochkin La-17C radio-controlled subsonic target drone); and the Ba-2, -7, and -9 (ASN-2, -7, and -9) radio planes. The Ba-9, developed by Xi'an, was designed to help train PLAN ship-based antiaircraft artillery (AAA) crews.

Technology controls remain a major impediment to indigenous Chinese UAV development. According to an internal Chinese government document dated July 8, 2008, obtained by the *Washington Times*, the Chinese plan to develop an advanced UAV using a strategy of combining civilian and military technology.⁹² Titled "National Defense Science and Technology Industry Military and Civilian Dual-Use Research and Development Special Project," the report describes a quest to develop, within 2 years, a high-altitude, long-endurance UAV with both civilian (aerial exploration, ground monitoring) and military (aerial inspection, electronic warfare) applications. At the Zhuhai Airshow in 2008, one of the scale models on display had features similar to the U.S. Global Hawk, a high-altitude, long-endurance UAV. But for it to even approach such a level of capability in such a short time, an internal government document notes that China must depend on international cooperation to supplement indigenous research efforts in order to "break through the core technologies of this type of aerial vehicle."⁹³

Guidance Options

A significant challenge for Chinese cruise missile employment is obtaining assured access to position, navigation, and timing (PNT) information without depending on access to the U.S. GPS constellation, the signals of which China fears the U.S. could deny them during wartime. Chinese analysts observe the critical role of GPS in navigation, flight path correction and adjustments, and overall enhancement of targeting accuracy of cruise missiles.⁹⁴ At present, Chinese cruise missiles may use the U.S. GPS as well as Russia's GLONASS satellite positioning system for navigation, which was slated to return to its full complement of 21 satellites (and 3 spares) by the end of 2009.⁹⁵ Importantly, China reached agreement with Russia in 2000 on use of GLONASS.

Still, China's ideal is guaranteed access to satellite PNT information. To that end, Beijing is developing its own Beidou geostationary satellite navigation system (北斗卫星导航定位系) to minimize reliance on foreign systems that may be blocked during conflict.⁹⁶ Sino-European disagreement concerning Beijing's access to Europe's nascent Galileo system has apparently intensified existing Chinese efforts to develop Beidou since Beijing had only limited access to receiver technology and was denied access to Galileo's military mode. China deployed its own Beidou 1 navigation constellation in 2007, but with only five geostationary Earth orbit (GEO) satellites, the system was limited to providing service from 70 to 140 degrees east longitude and 5 to 55 degrees north latitude. This limitation made Beidou 1 useful for China's immediate regional context but not for truly global operations. In that regard, China is deploying a 35-satellite constellation called Beidou 2, or Compass, which would provide global coverage and much-improved accuracy over Beidou 1.⁹⁷ China has launched 20 Beidou satellites and 16 remain fully operational.⁹⁸

Official media report that Beidou will be developed into a full, independent satellite PNT constellation called Compass. Having covered China and surrounding regions by 2012,⁹⁹ Compass will ultimately use five GEO and 30 medium Earth orbit (MEO) satellites.¹⁰⁰ Compass's commercial Open Service would offer "positioning accuracy within 10 m, velocity accuracy within 0.2 meters per second, and timing accuracy within 50 nanoseconds"¹⁰¹ while even more accurate signals coupled with system status updates would reportedly be available to the PLA. The radio frequencies used by Compass might overlay both Galileo's Public Regulated Service and possibly GPS's M-Code (a more jam-resistant U.S. military-only signal), thereby complicating adversary attempts to jam Compass during a conflict.¹⁰² Improvements in access to foreign and domestic positioning systems increase the accuracy of Chinese missiles and other position-dependent equipment, and development of Compass as a viable independent system could improve access to reliable signals in conflict.¹⁰³ Other Beidou navigation satellites and space remote sensing technologies also enhance precision strike capabilities.¹⁰⁴ China's first data

relay satellites, Tianlian I, I-02, and I-03, facilitate near-real-time communication among satellites and ground control.¹⁰⁵

Improved PNT capabilities are important to cruise missile performance (as already seen, reportedly, with the C-602/YJ-62 ASCM). According to ONI, PNT capabilities:

*allow a missile to fly a pre-programmed, indirect flight path to a target. This in turn allows for the possibility of launching multiple missiles in a coordinated attack, arriving at targets simultaneously and from different angles. Multiple missiles approaching the target at the same time from different directions increase the likelihood of penetrating a ship's defensive systems. The ability to engage targets at long ranges brings substantial advantages, but employing long range ASCMs requires effective OTH targeting. China may be planning to use OTH radar, satellites, and UAVs to detect targets and relay the information to the missile launch operators. ASCM terminal seekers should be capable of homing into a target once the missile seeker has identified the target in flight.*¹⁰⁶

Although the above wording sounds optimistic, and while finding the target for simultaneous time-on-target strikes is difficult, China's progress in satellite PNT and ISR will greatly improve the accuracy of its cruise missiles. Scott Bray states,

*China has elements of an OTH network already in place and is working to expand its horizon, timeliness, and accuracy. The range and effectiveness of both current and future systems vary widely depending on the anticipated target's characteristics, geometry, weather, surrounding traffic, sensor operator proficiency, etc. Regardless, the beginnings of an operational Chinese OTH network are already in place.*¹⁰⁷

Cruise Missile Platforms¹

As a major Chinese treatise on ASCMs points out, a given type of cruise missile can typically be launched from many different types of platforms.² The PLA has benefited from increased defense spending over the past decade, placing numerous new and modernized platforms into service that can launch cruise missiles. China has produced a new array of frigates and destroyers that carry sophisticated long-range ASCMs, and some PLAAF/PLAN Aviation aircraft can carry LACMs in addition to ASCMs. *Song*-, *Kilo*-, and *Yuan*-class diesel submarines are equipped with Russian and indigenous ASCMs. *Shang*-class SSNs have or will have ASCMs as will their *Tang*-class follow-ons when they enter service. China thus appears to be making a concerted effort to develop its ASCM delivery capabilities from air, surface, and subsurface platforms simultaneously. In the near term, China and the PLAN will likely continue to expand their ASCM inventory and capability to deliver those weapons down range with precision and lethality.

Surface Combatants

Since the early 1990s, China has deployed four Russian-purchased *Sovremenny*-class destroyers and nine classes of indigenous destroyers and frigates.³ Though the PLAN is still one of the world's largest navies, the surface force has decreased in number but increased rapidly in quality, defensibility, effectiveness (due to platforms fielding such weapons as antiship missiles), and diversity of possible missions.⁴ For now, this force remains part of an emphasis on improving quality and antiaccess capability; the PLAN as a whole currently has only a limited ability to protect sea lines of communication (SLOCs).

In William Murray's view, China's "marked reliance on advanced ASCMs suggests strongly that the PLA leadership regards every surface combatant to be the aquatic equivalent of a missile Transporter-Erector-Launcher (TEL)."⁵ Many surface vessels and conventionally powered submarines are apparently being prioritized as ASCM delivery platforms. This approach to ASUW offers China potent possibilities:

Beijing's ongoing investment in increasingly modern (and therefore increasingly quiet) ASCM-firing diesel submarines reflects a determination to overwhelm and destroy surface ships operating within at least 100 miles of the shallow waters of the Yellow and East China Seas, including Taiwan. . . . This PLA reliance on large numbers of ASCMs as a means of deterring and defeating opposing surface naval forces represents a significant

*challenge for a potential adversary, and suggests specifically that the U.S. Navy's post-Cold War ability to conduct high-volume uncontested maritime strike operations from surface warships in the Western Pacific has at least temporarily ended.*⁶

Over the past few decades, surface vessels have increased in value because they serve as a platform for such weapons as cruise missiles.⁷ According to Scott Bray,

*Much of [the] 'remarkable rate' of capability growth for the surface combatant force is the result of improved ASCM range and performance. . . . Between 2000 and 2009, the number of major surface combatants capable of carrying long-range ASCMs has tripled from 12 to 36. Additionally, the PLA(N) has built more than 50 small combatants with long-range ASCMs. . . . Similar ASCM improvements also impact the submarine force, naval air force, and coastal defense forces.*⁸

Indeed, as Murray notes, "Every surface warship launched by China in the past decade (with the possible exception of the new Type 072 LPD and the nine or so LSTs that were launched five or six years ago) carries YJ-series ASCMs."⁹

*In contrast to the fleet just a decade ago," the 2011 DOD report documents, "many PLA Navy combatants are equipped with advanced air-defense systems and modern ASCMs, with ranges in excess of 185 km. These capabilities not only increase the lethality of PLA Navy platforms, particularly in the area of ASuW, but also enable them to operate beyond the range of land-based air defenses."*¹⁰

For example, "China has deployed some 60 of its new Houbai-class (Type 022) wave-piercing catamaran hull missile patrol boats. Each boat can carry up to eight YJ-83 ASCMs."¹¹ As Murray elaborates:

*ASuW that emphasizes the destructive potential of advanced cruise missiles is already prevalent in China's surface fleet. Nearly every PLAN surface combatant carries up to 16, and typically eight . . . ASCMs. Exceptions are the Luyang II destroyers, which carry eight 151 nm-range YJ-62,¹² and the four Sovremenny-class destroyers China purchased from Russia that can each employ eight 135 nm-range supersonic SS-N-22 ASCMs. Reliance on . . . ASCMs is reflected especially strongly in the PLAN's sixty-odd Houbai-class fast attack wave-piercing catamarans, each of which can carry eight 97 nm-range YJ-83 ASCMs.*¹³

In the event of actual combat, China's most advanced surface combatants would likely be assigned offensive attack missions against aircraft carriers due to their robust "carrier killer" capabilities.¹⁴ The PLAN's four *Sovremenny*-class destroyers carry the SS-N-22 Sunburn "and more than 150 other . . . destroyers, frigates, and fast attack craft

[are] armed with less capable missiles.”¹⁵ All ASCM carriers are not equal, to be sure, but this overall emphasis on cruise missiles is striking.

Destroyers

China is rapidly upgrading its previously backward destroyer fleet with four Russian *Sovremenny* destroyers and five new incrementally-improved classes. The *Sovremenny* missile destroyers, stationed in the East Sea Fleet, give the PLAN unprecedented anti-surface and anti-air warfare (AAW) capability. Two Project 956E *Sovremenny* missile destroyers, built in 1996 and entering service in 1999 and 2001, are now designated *Hangzhou* (Hull 136) and *Fuzhou* (Hull 137). Two improved Project 956EM variant vessels with enhanced ASCMs, wide-area air defense systems, and sensors—*Taizhou* (Hull 138) and *Yangzhou* (Hull 139)—entered service in 2005 and 2006, respectively. The first two *Sovremennys* each have eight Raduga 160 km-range SS-N-22 Sunburn (Moskit 3M-80E) (2 quad) launchers; the second two have 240 km-range Moskit 3M80MVE variants.¹⁶

The PLAN currently possesses 12 Type 051 *Luda*-class missile destroyers. Designed for surface warfare, with limited anti-air and anti-submarine warfare (ASW) missions, and built between 1970 and 1991, these aged vessels were refitted in the 1990s to improve their surface- and air-defense capabilities, and each has 16 YJ-83 ASCM launchers.¹⁷ A single Type 051B *Luhai*-class multirole missile destroyer, *Shenzhen* (Hull 167), entered service in 1998 and was refitted in 2004. It has two 16 YJ-83 ASCM launchers.¹⁸ Dual type 051C *Luzhou*-class air-defense guided missile destroyers, commissioned in the North Sea Fleet in 2006 and 2007, respectively, have a marinized SA-20 SAM. Built to take the SA-20 to sea and thereby rectify AAW deficiencies, the *Luzhous* also have eight YJ-83 ASCM launchers each.¹⁹ Based on the older Type 051B multirole destroyer’s hull design, *Shenyang* (Hull 115) and *Shijiazhuang* (Hull 116) have been given the long-range Russian SA-N-20 SAM system.²⁰ Two hulls of the Type 052A *Luhu*-class, a multirole missile destroyer, *Harbin* (Hull 112) and *Qingdao* (Hull 113), entered service in 1994. This first Chinese modern multirole surface combatant with comprehensive surface strike, air defense, and ASW capabilities is also the first Chinese-built warship to be fitted with a significant suite of sophisticated Western-designed weapons systems and sensors. Each vessel has 16 YJ-83 ASCM launchers.²¹

Two Type 052B *Luyang-I*-class multirole area air defense missile destroyers, commissioned in 2004, are, at 154 m long and with 6,500 tons displacement, larger than any destroyers China has previously built. New, indigenous, and imported weapon and sensor systems give *Guangzhou* (Hull 168) and *Wuhan* (Hull 169) enhanced air defense and basic ASW capabilities. The destroyers are fitted with 16 YJ-83 ASCM launchers. The PLAN’s eight Type 052C *Luyang-II*-class area air defense guided missile destroyers are based on the Type 052B (*Luyang-I* class) destroyer’s hull. The first two vessels in the series—*Lanzhou*

(Hull 170), commissioned in 2004, and *Haikou* (Hull 171), commissioned the following year—possess the indigenously-produced vertically launched HQ-9 SAM system and the phased array Dragon Eye radar, which has a superficial resemblance to U.S. SPY-1 phased array radars.²²

Antiship cruise missiles, together with SAMs, are thus increasing the effective operational range of PLAN destroyers.

The long-range SAM systems [that the Luzhou and Luyang II destroyers possess] will provide Chinese surface combatants with an area air defense capability as they operate farther from shore and outside of the protection of land-based air defense assets,” Scott Bray extrapolates. “Under the protection afforded by these advanced area air defense destroyers, which are also equipped with long-range ASCMs, the Chinese Navy can operate combatants such as two recently acquired Sovremenny II [destroyers]. These long-range engagement and air defense capabilities now being fielded by the PLA(N) give China a significantly improved capacity for operations beyond the littoral in support of SLOC protection.”²³

Frigates

The inventory of frigates has likewise improved substantially, with four new classes of indigenously constructed destroyers (the later two based on the earlier two) deployed since the early 1990s.²⁴ Starting in the 1990s, China’s 26 relatively obsolete Type 053 *Jianghu*-class missile frigates have been supplemented by the PLAN’s 14 Type 053H2G and 053H3 *Jiangwei*-class multirole missile frigates. The four 053H2G vessels have six YJ-83 (two triple) launchers each;²⁵ the 10 vessels of the improved Type 053H3 (*Jiangwei*-II class) and all subsequent frigates mentioned in this paragraph possess eight YJ-83 ASCM launchers each.²⁶ In 2005, the PLAN received two *Jiangkai I*-class (Type 054) multirole frigates, *Ma’anshan* (Hull 525) and *Wenzhou* (Hull 526). These vessels boast French-made diesels and a combination of Russian and Chinese weapon systems as well as copied Dutch 30 mm Gatling gun point defense systems.²⁷ *Jiangkai I*s are the first class of surface warship that China has built more than two of since the 1990s. The 16 to 19 *Jiangkai II* (Type 054A) air defense frigates have vertical launch cells and phased array and guidance radars.²⁸ Both the *Jiangkai I* and *II* frigates carry eight YJ-83 launchers.

China’s fast-attack craft include 60+ stealthy new-generation *Houbei*-class Type 2208 wave-piercing missile catamarans. The high-speed (cited by some analysts as exceeding 50 knots), wave-piercing, low observability (radar cross-section-reduced) catamaran, which is based on an Australian ferry design, may become a key component of the new PLAN (along with submarines). It might be given the mission to quickly destroy Taiwan’s

surface force if it leaves port in the event of hostilities.²⁹ This impressive antisurface weapons system, consisting of eight YJ-83A ASCMs with a range of approximately 97 nm (180 km),³⁰ would be highly effective in attacking surface warships in the waters around China. However, their limited endurance would not allow them to operate for extended periods at much greater distances, and their operational capability in heavy seas remains unclear. The 2208's minimal in-water profile and high speeds could also make it difficult to hit with torpedoes.³¹ One Chinese source suggests the use of small, fast craft to attack CSGs, in possible anticipation of the 2208 *Houbei* missile catamaran.³² This option would represent modern, cruise missile-focused realization of swarming tactics, a traditional PLAN concept.³³

Table 4.1. PLAN Surface Cruise Missile Platforms¹

Class	Manufacturer	Role	Cruise Missiles	In Service	First Hull Commissioned
<i>Luyang II</i> (Type 052C)	Jiangnan/Changxing Island shipyards	Destroyer (area air-defense)	2 x 4 YJ-62	6	2004
<i>Luyang I</i> (Type 052B)	Jiangnan Shipyard	Destroyer (area air-defense)	2 x 4 YJ-83	2	2004
<i>Luzhou</i> (Type 051C)	Dalian Shipyard	Destroyer	2 x 4 YJ-83	2	2006
<i>Sovremenny</i> (Project 956E/956EM)	North Yard, Russia	Destroyer	2 x 4 SS-N-22 Sunburn	4	1999
<i>Luhu</i> (Type 052A)	Jiangnan Shipyard	Destroyer	4 x 4 YJ-83	2	1994
<i>Luda</i> (Types 051DT/051G/051G II)	Dalian Shipyard	Destroyer	2 x 4 YJ-83	4	1991
<i>Luda</i> (Types 051/051D/051Z)	Various	Destroyer	2 x 3 HY-1	8	1971
<i>Luhai</i> (Type 051B)	Dalian Shipyard	Destroyer	4 x 4 YJ-83	1	1999
<i>Jiangkai II</i> (Type 054A)	Huangpu/Hudong-Zhonghua shipyards	Frigate (air defense)	2 x 4 YJ-83	16-9	2008
<i>Jiangkai I</i> (Type 054)	Hudong-Zhonghua/Huangpu shipyards	Frigate	2 x 4 YJ-83	2	2005
<i>Jiangwei II</i> (Type 053H3)	Huangpu/Hudong-Zhonghua shipyards	Frigate	2 x 3 YJ-83	10	1998
<i>Jiangwei I</i> (Type 053H2G)	Hudong-Zhonghua Shipyard	Frigate	2 x 3 YJ-83	4	1991
<i>Jianghu I/II/V</i> (Type 053H/053H1/053H1G)	Hudong-Zhonghua/Jiangnan/Huangpu shipyards	Frigate	2 x 2 SY-2	22	Mid-1970s
<i>Jianghu IV</i> (Type 053HTH)	Hudong-Zhonghua Shipyard	Frigate	2 x 2 SY-2	1	1986

Class	Manufacturer	Role	Cruise Missiles	In Service	First Hull Commissioned
<i>Jianghu III</i> (Type 053H2)	Hudong-Zhonghua Shipyard	Frigate	2 x 4 YJ-83	3	1986
<i>Houbei</i> (Type 022)	Various	New-generation, fast-attack craft (missile)	2 x 4 YJ-83	60+	2004
<i>Houjian/Huang</i> (Type 037-II)	Huangpu Shipyard	Fast-attack craft (missile)	2 x 3 YJ-83	5–6	1991
<i>Houxin</i> (Type 037/1G)	Qiuxin/Huangpu shipyards	Fast-attack craft (missile)	2 x 2 YJ-83	16	1991
<i>Huangfeng</i> (Type 021) (Osa I Type)	?	Fast-attack craft (missile)	1 x 4 SY-2	11	1985

Source

¹ Reproduced from Erickson, 103–105. Data on cruise missiles from “CSS-N-4 ‘Sardine’ (YJ-8/C-801); CSS-N-6 (YJ-83/C-802/Noor); YJ-62/C-602; YJ-82; CY-1,” *Jane’s Naval Weapon Systems*, August 13, 2012; “CSS-N-1 ‘Scrubbrush’ (SY-1/HY-1/FL-1); CSS-N-2 ‘Safflower’ CSSC-2 ‘Silkworm’; CSS-N-3/CSSC-3 ‘Seer-sucker’ (HY-2/FL-3A),” *Jane’s Naval Weapon Systems*, November 30, 2012; and OSD, *China Military Report 2011*, 4.

Together, PLAN frigates and destroyers total approximately 79 major surface combatants.³⁴ Launches of new frigates and destroyers represent a “dramatic shift” away from numerous, obsolete, and limited capability combatants towards a leaner, vastly more capable fleet.³⁵ These modernized and credible ASCM platforms are likely to support China’s foreign policy objectives in the near term vis-à-vis Taiwan and, in the longer term, resource and trade security. Table 4.1 lists active PLAN surface ship classes and their estimated ASCM weapon load-outs.

Submarines

China is currently developing and producing as many as six classes of submarines: two classes of indigenously designed diesel vessels (including the *Yuan*/Type 041) and four classes of nuclear vessels (the *Shang*-class/Type 093; *Jin*-class/Type 094 SSBN; Type 095 *Tang*-class SSN, and Type 096 SSBN follow-on versions). China now has the largest

Table 4.2. PLAN Submarines¹

Class	Manufacturer	Role	ASCMs	In Service	First Hull Commissioned
<i>Shang</i> (Type 093)	Bohai Shipyard	Attack, nuclear-powered	YJ-82; CH-SS-NX-13	2	2006
<i>Han</i> (Type 091/091G)	Huludao Shipyard	Attack, nuclear-powered	YJ-82	3	1980
<i>Kilo</i> (Project 877EKM/636)	Various Russian shipyards	Patrol, diesel-powered	SS-N-27B/Sizzler	12	1995
<i>Yuan</i> (Type 041)	Wuhan/Changxing Island shipyards	Patrol, diesel-powered (likely air-independent-power)	YJ-82; CH-SS-NX-13	8-9	2006
<i>Song</i> (Type 039/039G)	Wuhan/Jiangnan shipyards	Patrol, diesel-powered	YJ-82; CH-SS-NX-13	13	1999

Source

¹ Reproduced from Erickson, 102. Data on cruise missiles from: “CSS-N-4 ‘Sardine’ (YJ-8/C-801); CSS-N-6 (YJ-83/C-802/Noor); YJ-62/C-602; YJ-82; CY-1,” *Jane’s Naval Weapon Systems*, August 13, 2012; and OSD, *China Military Report 2011*, 4.

conventional submarine force in the world, has more submarines under construction than any other country (which suggests satisfaction with technology and quieting), and appears to have matched submarine capabilities with mission requirements.³⁶ DOD states that “China has expanded its force of SSNs. Two second-generation *Shang*-class (Type 093) SSNs are already in service and as many as five third-generation Type 095 SSNs will be added in the coming years. When complete, the Type 095 will incorporate better quieting technology, improving its capability to conduct a range of missions from surveillance to the interdiction of surface vessels with torpedoes and ASCMs.”³⁷

Prioritized as missile delivery platforms, Chinese submarines appear well on their way to becoming the “aquatic TELs” William Murray describes. Chinese analysts perceive submarine-launched cruise missiles (SLCMs) to have advantages over those launched from land. According to *Aerospace Control*, a cruise missile launched from a submarine is a long-range, accurately-guided weapon, small in size, light in weight, with a low flight path, and a strong ability to attack and destroy hard targets.³⁸ China’s growing submarine force may permit it to use ASCMs or LACMs (if proper variants are developed) against radars and support facilities in East Asia. The PLAN currently has two major SLCMs, the 21–27 nm range C-801/YJ-82 and the 120 nm range SS-N-27B Sizzler/Klub ASCM.

China has already imported capable ASCMs to equip its Russian-built attack submarines, as Murray explains: “China in 2007 took delivery of the last of eight *Kilo* 636M diesel-electric submarines purchased in 2002 (along with modern wire-guided and wake homing torpedoes) with the Russian SS-N-27B ASCM. These missiles can deliver a 200 kg warhead to a range of 120–160 nautical miles, with the terminal phase consisting of a Mach 2.9 ‘zig-zag flight path.’”³⁹ These submarines supplement two Project 877EKM and two Project 636 *Kilo* variants the PLAN already operates.⁴⁰

Indigenously produced submarines are being similarly outfitted. DOD’s 2011 report states that the PLAN’s 13 *Song*-class submarines “each can carry the YJ-82 ASCM,” and that “The *Song* SS, *Yuan* SS, *Shang* [attack submarines] and the still-to-be-developed Type 095 [SSN] will be capable of launching the new CH-SS-NX-13 ASCM once the missile completes development and testing.”⁴¹ As the report elaborates, “China has expanded its force of nuclear-powered attack submarines (SSN). Two second-generation *Shang*-class (Type 093) SSNs are already in service and as many as five third-generation Type 095 SSNs will be added in the coming years. When complete, the Type 095 will incorporate better quieting technology, improving its capability to conduct a range of missions from surveillance to the interdiction of surface vessels with torpedoes and ASCMs.”⁴² China’s 12 *Kilo*-, 13 *Song*-, 8–9 *Yuan*-, and two *Shang*-class attack submarines are “capable of firing advanced ASCMs.”⁴³ In William Murray’s estimation, “One could logically surmise therefore that the CH-SS-NX-13 ASCM will be a significant threat to surface naval forces. Until further performance data regarding the CH-SS-NX-13 are available observers can only speculate as to how advanced the missile will be, but there is little reason to believe it will not be a considerable improvement to the approximately 20 nm-range submarine-launched subsonic C-801 ASCM the *Song* currently carries.”⁴⁴

From 1995 to 2006, China commissioned 36 submarines.⁴⁵ From 2002 to 2004, the PLAN launched 13 submarines from four different classes: two classes of indigenously designed diesel vessels (*Song*/Type 039 and *Yuan*/Type 041) and two classes of nuclear vessels (the *Shang*-class/Type 093 SSN and *Jin*-class/Type 094 SSBN).⁴⁶ As of 2012, there were approximately 53 attack submarines—48 conventionally powered and five nuclear-powered.⁴⁷

Thirteen Type 039 *Song*-class diesel-electric submarines have been launched with production of three successively refined versions ending in 2004. *Song* submarines carry radar active homing YJ-82 ASCMs with a range of 40 km (22 n miles) at 0.9 Mach and carrying a 165 kg warhead.⁴⁸ The PLAN has 12 *Yuan*-class conventional submarines in service.⁴⁹ According to *Jane’s*, this advanced indigenous submarine “is believed to incorporate air-independent propulsion using Stirling engine technology.” It is fitted with YJ-82 ASCMs with similar parameters to those on the *Song* except for the use of inertial cruise guidance.⁵⁰

China's two 093 SSNs reportedly carry a radar homing variant of the YJ-82.⁵¹ One Chinese analysis, possibly employing outdated or alternative nomenclature for the YJ-82, claims that the 093 may be equipped with "Eagle Strike" YJ-12 (鹰击-12) supersonic ASCMs.⁵² Another states that this cruise missile has been developed as part of a larger Chinese quest for improved cruise missiles, particularly submarine-launched variants.⁵³

Finally, a large conventionally powered submarine was launched from Wuchang Shipyard in September 2010, though it has apparently not yet been formally commissioned. Known as the "Qing (Type 043)" in Internet forums, it appears to have significant missile capacity in its large sail.

Attack submarines are viewed as a vital ASCM launch platform. A Chinese textbook for C2/fire control experts, authored by a captain who serves as an instructor at the PLAN Submarine Academy in Qingdao, emphasizes the importance of SLCMs for the navy, implicitly in a Taiwan contingency in which the United States has intervened. According to this source, the PLAN is presently working to

*equip attack submarines with long-distance, high speed (Mach), low-altitude flight, high accuracy, strong interference-resistance antiship missiles with the combat capability to attack enemy surface ships from mid- to long-range. [This] is one of the major issues that must be resolved immediately . . . in the course of future operations against the enemy, the ability to use antiship missiles to attack enemy surface ships from long distance will greatly increase the combat capability and deterrence ability of our navy's attack submarines.*⁵⁴

The instructor's claim appears to be based on both the YJ-82 and the 120 nm range SS-N-27 B Sizzler/Klub (China acquired the latter after his writing, but he seemed to anticipate it), and the inherent tradeoffs between their respective capabilities.⁵⁵ He begins, "under modern combat conditions, the main combat method for attack submarines is to fire antiship missiles from underwater to attack enemy surface ships. The organization and control of firing missiles therefore has universal [普遍] meaning."⁵⁶

If a Chinese submarine is monitoring an enemy surface ship on sonar, it could in theory determine the ship's bearing and even its range⁵⁷ (course and speed would also be useful although less important).⁵⁸ If the target is within YJ-82 range and the submarine can detect the target with sensors in real time, a firing solution could be developed onboard the submarine without outside communication. The instructor refers to this scenario as the "present point method." The problem is that radar detection distance is limited (which the author acknowledges directly), and using active sonar could trigger an attack from enemy ASW forces,⁵⁹ an issue that he fails to mention. The author also seems optimistic that "increasing submarine-launched anti-ship missiles' effective range has become the

inevitable trend” and cites an unspecified missile whose range “has surpassed 500 km” (probably the tactical air-to-surface missile [TASM], a former U.S. weapon).

The author stresses, however, that OTH targets will be beyond the submarine’s sensor range. To target a ship at such distances, a submarine would need to use what the captain calls the “future point method,” which probably refers to predicting future location based on disparate targeting information provided to the submarine via radio. The accuracy of the data can be degraded by computer processing issues, data latency, and, particularly for long-range missiles, weapon flight time, all of which make a successful attack by cruise missiles less likely. Targeting errors could also be introduced by changes in the targeted ship’s course and speed and even by compatibility challenges in different equipment, some of which may be Russian as opposed to Chinese in origin. The submarine would need to have some form of antenna to receive cueing data. *Ming*- (of which the PLAN has 19–20 hulls), *Song*-, and *Yuan*-class submarines may use a floating wire antenna; raising an antenna could render a submarine more vulnerable to attack. A number of cruise missiles must be prepared for firing: they must be turned on, have their gyroscopes spun up, and undergo digital tests. Water damage to their electrical circuits must be avoided during underwater launch.⁶⁰ By the time of launch, therefore, shooting information will be out of date to some extent and the target will have moved. This imposes a “circle of uncertainty” and makes the cruise missile’s search pattern important. A less sophisticated cruise missile such as the YJ-82 may go out on a specific bearing for a set distance until its radar turns on and sweeps. If it detects a target, it will then attack that target (which may or may not be the ship the missile was originally fired at). If it does not detect a target in time, the missile may exhaust its fuel supply and fall harmlessly into the sea. A more capable missile may have sufficient fuel to make a more thorough search.

The Submarine Academy instructor thus clearly realizes the tradeoffs inherent in reliance on off-board targeting and sensor fusion for long-range applications. He therefore asks how China can develop a reconnaissance strike complex sufficient to get accurate information in time to strike the intended target. Sky wave radar is insufficiently accurate. “Relay stations” are therefore necessary as part of a distributed sensor network for data fusion.⁶¹ A repeater, he implies, may be used to update target data to pass to the submarine. This process requires proper operation and coherent, rapid communications. Command and control issues might raise the question of whether the PLAN will give its commanding officers the same decisionmaking authority the U.S. Navy gives its officers with regard to dynamic, long-distance targeting decisions.

Regardless of how it is targeted, an SLCM or other ASCM may be defeated if the surface ship releases chaff, cut to certain lengths to reflect given wavelengths, as researchers at Dalian Naval Academy are well aware.⁶² Electronic jamming may also mislead it.⁶³ In an effort to overcome these obstacles and increase the probability of cruise missiles

hitting their targets, the previously mentioned PLAN Submarine Academy instructor argues that “to ensure that the anti-ship missile attack reaches relatively high effectiveness [in terms] of locking on targets, designed defense penetration ability, and target accuracy requirements, it is necessary to organize the firing of at least two anti-ship missiles simultaneously.” He also suggests that submarines may fire SLCMs in coordination with shore bases as part of simultaneous saturation attacks.⁶⁴

Aircraft

The PLAAF and PLAN Aviation forces currently possess 2,300 operational combat aircraft, of which 490 are capable of conducting operations against Taiwan without aerial refueling.⁶⁵ The military aircraft are outfitted with a variety of increasingly advanced weapons systems. In some cases, particularly involving cruise missiles, these systems have extended the operational utility of otherwise obsolescent platforms. Despite ongoing bottlenecks in several areas (including ongoing reliance on imports of Russian planes and their components, especially jet engines), in aggregate this acquisition of large amounts of sophisticated, lethal equipment in several important categories has shifted the balance of military power to the PRC probably permanently. The resulting inventory of modern aircraft and associated weapons is increasing China’s ability to achieve air superiority over the Taiwan Strait and even the island itself.

People’s Liberation Army Air Force

The PLAAF is transitioning from a past mission of territorial air defense to both offensive and defensive operations. Chinese military analysts likewise highlight the importance of air and space power in national security and call for development and deployment of aerospace-based weapons systems and platforms.⁶⁶ Indeed, over the past two decades, China has expended great effort to turn its air force from its old subsidiary supporting role to more independent and offensive missions. This has involved both a more aggressive procurement program and a renewed domestic defense industrial renovation to produce a new generation of fighter aircraft and to refit and modernize the air force bomber fleet.⁶⁷ These efforts involve fourth-generation Russian fighters such as the Su-27 and Su-30, air defense systems, and new domestically produced fighter aircraft such as the J-10.⁶⁸

China has already purchased a variety of Russian precision-guided munitions with which it might equip its aircraft including the Kh-29 antiship missile (10 km range), Kh-31P antiradiation missile (110 to 200 km range), Kh-59ME antiship missile (115 km range), and the KAB-1500 laser-guided munition.⁶⁹ China’s military aircraft are

Table 4.3. PLAAF Fixed-wing Aircraft with Cruise Missile Capability¹

Type	Manufacturer	Role	Cruise Missiles	In Service	First Delivery
H-6	XAC	Bomber	YJ-63, YJ-81, YJ-83, KD-88	82	1968
JH-7A	XAC	Fighter (ground attack/strike)	YJ-81, YJ-83, YJ-91	83	2004
Q-5 Fantan	HAIC	Fighter (ground attack/strike)	YJ-81	120	1970
Su-30MKK Flanker	Sukhoi, Russia	Fighter (multirole)	Kh-31P, AS-13	73	2000
J-11B/BS ²	SAC Shenyang	Fighter (multirole)	YJ-91	96	2004
J-11A (Chinese kit-assembled Su-27SK)	SAC Shenyang	Fighter (multirole)	YJ-91	96	2001
Su-27SK Flanker-B	Sukhoi, Russia	Fighter (multirole)	Kh-31P	43	1992
J-10B	CAC	Fighter (multirole)	YJ-81, YJ-83	10	2009
J-10A/S	CAC	Fighter (multirole)	YJ-81, YJ-83	216	2001

Sources

¹ Reproduced from Erickson, 114–116. Cruise missile payload capability from the entries for specific aircraft in *Jane's All the World's Aircraft*.

² Indigenized Su-27 variant. Total includes one development aircraft used for system trials.

already outfitted with a variety of increasingly advanced weapons systems. As William Murray explains, like the PLAN, “The PLAAF and PLAN Aviation have also invested in high-performance ASCMs, with many images appearing on the Internet of B-6 bombers and smaller tactical aircraft carrying ASCMs.”⁷⁰

The PLAAF currently deploys 82 H-6 (B-6) twin-engine, medium-range bombers, derivatives of Russia's Tupolev Tu-16/Badger, as its medium- to long-range strategic and tactical air strike platform and continues to produce slightly improved versions of this aircraft. Bombers continue to lag, however, and no evidence suggests that the PLAAF retains a nuclear mission. The PLAAF uses 10 H-6U variants as aerial refueling tankers.⁷¹ Some H-6s also conduct reconnaissance and electronic intelligence (ELINT).⁷² Since 2004, the PLAAF has been supplementing its ground attack capabilities with JH-7A fighter-bomber aircraft, with 83 now in service.

The PLA accepted shipments of 26 Su-27s in 1992, 24 in 1995–1996, and 28 in 2002.⁷³ The PLAAF currently operates more than 150.⁷⁴ Shenyang Aircraft Corporation has assembled over 100 aircraft kits indigenously as the J-11, which has served as a test

bed for the indigenous WS-10A turbofan engine and perhaps even for the associated indigenous radar and fire control system as well as the PL-12 active-guided AAM.⁷⁵ The PLAAF now deploys 96 of the kit-assembled J-11A and 96 of the J-11B/BS indigenous and improved variant. Ten Su-30MKK Flanker two-seat, twin-engine multirole fighter aircraft, currently China's most capable multirole aircraft/fighters, were received in 2000, 28 in 2001, 38 in 2003, and 24 in 2004, for a total of 100 to date, 73 of which are currently in operation in the PLAAF and 24 in the PLAN. Thus, China might have obtained 268 fourth-generation aircraft as early as 2004.⁷⁶

The indigenous fourth-generation J-10 multirole fighter entered serial production in 2006 with 216 of the A/S variant and 10 of the B variant now in service in PLAAF units. This fighter has demonstrated in-air refueling capability through publicly documented exercises. It is thought to be based on Israel's discontinued Lavi (which itself exploited U.S. F-16 technology) and to approach the performance parameters of Washington's F-16 and the European consortium-developed Eurofighter⁷⁷ with its 125 km radar detection range and ability to fire active-guided PL-12 AAMs as well as deliver precision-guided munitions (PGMs).⁷⁸ It is capable of all-weather day/night operation, and in some performance parameters the J-10 may even approach the capabilities of the F-16 and Mirage 2000.⁷⁹ China has already purchased a variety of Russian precision-guided munitions with which it might equip its aircraft, including the Kh-29 antiship missile (10 km range), Kh-31P antiradiation missile (110 to 200 km range), Kh-59ME antiship missile (115 km range), and KAB-1500 laser-guided munition.⁸⁰ The J-10 may also use YJ-81, YJ-83K, and YJ-83AK ASCMs.⁸¹

Regarding further acquisition of fixed-wing aircraft, DOD states:

*China continues to show interest in procuring Su-33 carrier-borne fighters from Russia. Since 2006 China and Russia had been in negotiations for the sale of 50 Su-33 Flanker-D fighters at a cost of up to \$2.5 billion. These negotiations reportedly stalled after Russia refused a request from China for an initial delivery of two trial aircraft. Russian defense ministry sources confirmed that the refusal was due to findings that China had produced its own copycat version of the Su-27SK fighter jet.*⁸²

Additionally, negotiations reportedly resumed for purchase of 34 IL-76 transport aircraft and four IL-78 aerial refueling tankers. While the two sides agreed to the sale for \$1.045 billion in 2005, Russia has refused to deliver the planes, citing higher manufacturing costs and concern that China's defense industries may reverse-engineer the aircraft for indigenous production. Russia is attempting to increase the contract to \$1.5 billion. Beijing has no other source for large aircraft to augment its military AEW&C capabilities.⁸³

PLAAF analysts maintain that while cruise missiles are playing an increasing role in modern warfare, a modern, well-developed air force remains a critical arm of the military

and can perform many functions that cruise missiles cannot. The issue is how to integrate airborne weapons systems, including LACMs, with various components of the air force.⁸⁴

LACMs and improved ability to launch them from aircraft may enable China to destroy Taiwan's aircraft while they are on the ground or in hardened shelters. Though they are not yet introduced into the force, at least two types of bomber-launched 500 kg warhead LACMs are being developed with 1,500 km ranges and 10 m accuracies.⁸⁵ Such missiles could presumably threaten hardened aircraft revetments including the cave entrances to Taiwan's underground fighter shelters inside the mountain at Cha Shan Airbase on the east side of the island. Air-launched LACMs could be used to destroy the command and control nodes that would otherwise coordinate and direct the intercept of PRC air attacks, and they could be designated to destroy Taiwan's aircraft and airfields with submunitions.⁸⁶

Table 4.4. PLAN Fixed-wing Aircraft with Cruise Missile Capability¹

Type	Manufacturer	Role	Cruise Missiles	In Service	First Delivery
H-6G ²	XAC	Bomber (missile variant)	YJ-63, YJ-83, YJ-83A, KD-88	30-32	2005?
H-6D ³	XAC	Bomber (missile variant)	YJ-81, YJ-83	3?	1985
JH-7A ⁴	XAC	Strike fighter/bomber	YJ-81, YJ-83, YJ-91	754	2004
JH-7 ⁵	XAC	Strike fighter/bomber	YJ-81, YJ-83, YJ-91	50-655	1998
Su-30MKK2 Flanker	Sukhoi, Russia	Fighter (interceptor/air defense)	YJ-91, AS-13	24	2004
J-11BH/BSH	SAC	Fighter (surface attack)	YJ-91	4+	?
J-10A/S	CAC	Fighter (surface attack)	YJ-81, YJ-83	24	?
Q-5 Fantan-A	HAIC	Fighter (surface attack/strike)	YJ-81	35	1970

Sources

¹ Reproduced from Erickson, 117–118. Cruise missile payload capability from the entries for specific aircraft in *Jane's All the World's Aircraft*.

² H-6D may be being replaced with H-6G.

³ Ibid.

⁴ Deliveries ongoing.

⁵ Ibid.

PLAN Aviation

Chinese naval aviation has traditionally lagged behind even the PLAAF, probably in part because during the Cold War Beijing had no hope of controlling airspace on its maritime periphery (in contrast to the PLAAF's useful, if limited, role in safeguarding China's airspace and contesting the airspace over North Korea in conjunction with major Soviet assistance during the Korean War). PLAAF-PLAN Aviation coordination still needs improvement, but recent equipment upgrades and enhanced doctrine and training will increase China's prospects of conducting effective joint operations in the future. Already, the navy controls a formidable land-based air force.

The PLAN uses the H-6D bomber variant, which is equipped with YJ-6 ASCMs, for missile attack.⁸⁷ The obsolescent H-6 design suffers from low payload and short range. However, the aircraft may have been given a new mission to destroy radars, command and control sites, and other fixed points on Taiwan: the newer H-6H has been fitted with YJ-63/KD-63 LACMs. Other H-6 variants already carry YJ-6, YJ-61, and YJ-81 cruise missiles.⁸⁸ In recent H-6 variants, cruise missiles have replaced guns on underwing pylons with two missiles on the H-6D and H-6H, four on the H-6G, and six on the H-6K.⁸⁹ One Chinese source terms the H-6 "another strong platform for China's cruise missiles."⁹⁰ China's H-6G bombers, of which the PLAN has 30, may be in the process of replacing the older H-6D.

In addition, roughly 50 to 65 JH-7s (also designated FB-7 or FBC-1 Flying Leopard), a two-seat, twin-engine fighter-bomber surface-strike aircraft, are in the PLAN inventory with the first delivered in 1998. They complement such multirole and strike aircraft as the Su-30MK2 and J-10.⁹¹ The improved formal production variant JH-7A, commissioned in 2004, has achieved the overall performance level of Western fighters introduced in the 1960s to 1980s.⁹² The JH-7A can carry four YJ-81, YJ-83K, YJ-83AK, or YJ-91 missiles. The PLAN has five regiments of these aircraft for a total of roughly 75 in operation today.⁹³

Sukhoi has developed an improved naval aviation-specialized variant of its Su-30 for the navy. The Su-30MK2 Flanker fighter-interceptor has an impressive combat radius (1,600 km without refueling; 2,600 km or 3,500 km with one or two Il-78 refuelings, respectively). The 24 received so far have improved engines, new radar, antiship strike capability, and an improved electronic-warfare and -countermeasures suite.⁹⁴ A reported Su-30MK3 variant has additionally received an improved engine and new radar to better support advanced antiship missile employment.⁹⁵ *Jane's* assesses these latter Su-30 variants as offering the PLA "world-class all-weather strike" capabilities for the first time⁹⁶ and suggests that all China's Su-30s may ultimately be upgraded to the MK2 standard.⁹⁷ The PLAN's more capable fighter-ground-attack aircraft also include 4+ J-11 BH/BSH and 24 J-10A/S airframes.

Additional research is required to gauge how much coordination exists within the PLAN between its ground-based naval air and surface/subsurface assets.⁹⁸ This assessment is all the more critical as the type and degree of coordination will necessarily vary depending on the maritime mission. Development and procurement of increasingly advanced aircraft will not automatically solve the lack of practical experience with them. As China's experience itself has demonstrated, mastering operations will involve the loss of expensive aircraft and hard to replace pilots.

Helicopters

In contrast to recent improvements in fixed-wing aviation, helicopters remain an area of PLA evolution, not revolution, and limited in number—perhaps because the PLA is wary of acquiring many until improved models are available. Most helicopters in the PLA's disproportionately small fleet (totaling as many as 700–800 airframes including roughly 500 for the ground forces, 100+ for the PLAN, and approximately 100 for the PLAAF) are either imports or copies of foreign models.⁹⁹ This deficiency was most directly exposed during the May 12, 2008, Sichuan earthquake when relief operations were limited significantly by lack of helicopters (particularly heavy lift). The PLAN operates 40 Z-8s, a derivative of France's Aerospatiale SA 321Ja/Super Frelon. They may carry the YJ-7 TV-guided antiship missile.¹⁰⁰ A Z-8F variant, powered by Pratt & Whitney engines, first flew in 2004. The PLAN also operates 25 units of a naval version (C) of the Zhi-9/Haitun (Z-9) multirole helicopter, licensed copies of France's Eurocopter AS 365N/Dauphin II. They may likewise carry the YJ-7.¹⁰¹ Recent Internet photos have shown a Z-9C with a C-70x or FL-X ASCM on it. Also in the inventory are 15 Ka-28/Helix naval helicopters purchased from Russia for its *Sovremenny* destroyers as well as for its indigenous Type 052B and Type 052C destroyers in recent counterpiracy deployments.¹⁰² The Ka-28's VGS-3 submarine-detecting dipping sonar and sonar buoys and any further improvements in rotary wing aviation will help the PLAN to address one aspect of its serious long-term weakness in ASW. China is attempting to remedy its helicopter deficiency further by developing joint ventures with foreign manufacturers; assembly/production of medium-sized helicopters in China has begun with Eurocopter. China typically imports several airframes of a given model and then produces additional units under license. Reportedly, the China Helicopter Research and Development Institute (CHRDI) is developing an indigenous WZ-10 advanced attack helicopter, albeit only for ground warfare applications at this time.¹⁰³

Regarding cruise missiles, the primary role of helicopters is to serve as over-the-horizon targeting (OTH-T) platforms rather than missile shooters. The latest unclassified ONI report states that “the use of shipboard helicopters, the Mineral-ME radar and

datalinks give the PLA(N) an improving capability to carry out OTH-T operations.”¹⁰⁴ Scott Bray elaborates that “the Chinese navy already employs shipboard helicopters, the Mineral-ME radar, and datalinks on board a significant portion of its fleet. As more of these systems are fielded and operator proficiency increases, the PLA(N)’s capacity for OTH-T operations will continue to grow. . . . The PLA(N) already practices employment of elements of its OTH-T system.”¹⁰⁵

A secondary role for helicopters, as cruise missile launch platforms, appears to be progressing more slowly. Experts at the PLA’s Army Aviation Research Institute in Beijing concluded a study of how to launch an AAM safely from a helicopter by stating that the subject is “extremely complicated” and that, both in China and the outside world, “research in this area is very immature.”¹⁰⁶

Ground-launch Land-attack Cruise Missiles

In addition to the naval and air platforms discussed above, China has also deployed ground-launched DH-10 LACMs (with a range of 1,500+ km) on road-mobile launchers.¹⁰⁷

Coastal Defense Cruise Missiles

China also deploys a number of ASCMs in an antiship role along the coast. Some systems are fixed and some are mobile. All are operated by the PLAN. They are envisioned to play an especially important role in defending naval bases, with ASCMs forming a “long-range firepower region” that can be used “to block an enemy warship fleet from getting close to the base, to stop enemy ships from getting close to conduct reconnaissance, conduct missile attack, or to deploy distant blockade barriers, [and] to attack [an] enemy warship fleet that is carrying out the task of blockading and patrol.”¹⁰⁸ Chinese coastal defense cruise missiles are also envisioned to play a role in Chinese blockade operations, either alone or in conjunction with ballistic missiles.¹⁰⁹

Table 4.5. PLAN Coastal Defense ASCMs¹

Type	Role	Manufacturer	Launch Platform	Range (km)	Payload (kg)	Speed	Guidance	Total in Service
YJ-62/ C-602	ASCM	CASIC Third Academy	8 × 8 wheeled TEL, 3 tubular ribbed mis- sile canisters, 20° -launch elevation. Typical bat- tery: 4 TELs, C2 vehicle, support vehicle	280+	210	Subsonic	Inertial/ Sat/active terminal guidance	120
HY-4/ C-201/ CSSC-7 “Sadsack”	ASCM/ turbojet	CASIC Third Academy		135	513; high explosive shaped charge warhead	Subsonic	Inertial/ multimode active-passive monopulse radar for terminal guidance	?

Source

¹ Erickson, 100–101. Additional data are from the entries for individual missiles in *Jane’s Naval Weapon Systems*.

Cruise Missile Employment Doctrine and Training

China's current military modernization efforts—including its new ASCM and LACM programs—seem focused on preparing for contingencies in the Taiwan Strait, which by necessity include the possibility of U.S. military intervention. The sea component of such a contingency would involve ASCMs and the land component LACMs. China appears to believe in the value of large-scale use of attacks in both domains.

Western analysts of Chinese military options vis-à-vis Taiwan may generally be divided into two schools of thought. One side holds that the military would undertake a measured approach involving a deliberate buildup of overwhelming military force for the purposes of coercing Taiwan to submit to China's demands in a crisis. The other side thinks that China would employ surprise to achieve rapid success against Taiwan before the United States had time to intervene. Cruise missiles would be important to either approach: as a deterrent measure in the former and as a means of attack in the latter. Chinese strategists have devoted considerable attention to the importance of seizing the initiative from the beginning of a military campaign. RAND Corporation researchers, in assessing China's emerging antiaccess strategies, quote one Chinese analyst as saying that “in a high-tech local war, a belligerent which adopts a passive defensive strategy and launches no offensive against the enemy is bound to fold its hands and await destruction.”¹

China's Emerging Sea Strike Capability

DOD's 2006 Quadrennial Defense Review (QDR) singled out China among all emerging powers as having “the greatest potential to compete militarily with the United States and field disruptive military technologies that could over time offset traditional U.S. military advantages absent U.S. counter strategies.”² In many ways, this asymmetric possibility has already been realized.

The precise strategic and political calculus behind PLAN modernization is outside the context of this inquiry into China's strike capability. Recent PLAN sea strike training in “complex” maritime environments and open source discussions concerning ASCM weapon and surface combatant delivery as well as platform capability suggest consistent themes that form a basis for Chinese experimentation against an anticipated CSG opponent defended by Aegis.

In a time of extreme political tension, Beijing could conceivably order air, tactical ballistic missile, and cruise missile strikes against Taiwan. Beijing's strategic requirement is to be able to launch a large-scale air raid against Taiwan's military and civilian targets and then be in a position to negotiate peaceful reunification on its own terms.

Aircraft carriers are seen as the main threat to the success of such PLA missions; therefore, Chinese strategists have long sought ways to target them effectively. As a book on cruise missiles published by the PLA Academy of Military Science suggests, "an aircraft carrier is a colossus; it will undoubtedly be the main target in future sea battles."³ Chinese specialists are acutely aware of carrier vulnerabilities, having conducted a wide variety of research apparently directed toward threatening aircraft carriers with "trump cards" such as cruise missiles. Aegis ships are also viewed as essential targets because, without their protection, attacking carriers directly is easier.⁴ Based on various writings and the logical employment of the forces China has been developing, in the event of a maritime conflict with U.S. forces the PLAN is likely to undertake massive multi-axis ASCM attacks against U.S. CSGs and their Aegis air defense perimeters. The PLAN's focused experimentation and training in long-range sea strike, its variety of indigenous ASCM weapons, and the modernization of ASCM delivery platforms may yield a high probability of success for this main effort.

Because cruise missiles can cross the Taiwan Strait rapidly at low altitude and can be launched from any direction, it can be difficult to implement an effective defense.⁵ The variety of Chinese missiles and launching platforms makes this statement true for some systems but not for others. A cruise missile must reach the elevation of the target it will hit and fly over land obstacles and civilian ships in its flight path. Cruise missiles must reach this altitude with a relatively slow climb rate (vice a fast dive rate), which introduces vulnerabilities an opponent might be able to exploit. An altitude of 300 to 500 feet, for example, might offer a radar horizon of roughly 30 miles. That height, in turn, introduces opportunities for SAM interceptors. Russia's export-version SA-20/S-300 is thought to be able to shoot down cruise missiles.⁶ The Patriot Advanced Capability-3 (PAC-3), which Taiwan has acquired from the United States, is a state-of-the-art system and can, in theory, shoot down cruise missiles if it has advanced tracking information from an airborne sensor.⁷ The question is how well it would perform and how many cruise missiles it could shoot down.

Doctrinal Direction

Potential Use in PLA Campaigns and Missions

PLA strategists appear to see cruise missiles as a key offensive strike weapon within the context of “active defense.” An expert at Nanjing Military Region Headquarters states that China should “use coastal-based cruise missiles to carry out surprise attacks” to “weaken the supporting capability of enemy bases, obstruct and interfere with the enemy’s aircraft carrier battle groups, and greatly frighten the enemies that take part in the intervention of our operations.”⁸ This outlook is reinforced in *Science of Campaigns* [战役学], an operationally and tactically focused doctrinal textbook that attempts to address the entire spectrum of military operations the PLA may undertake, published by China’s National Defense University in 2000 and 2006 editions.⁹ The 2006 version, which is significantly more sophisticated than its predecessor, devotes additional focus to joint operations, many of which involve the offensive use of cruise missiles and some of which involve defense against enemy cruise missiles.¹⁰ (For excerpts concerning potential cruise missile missions, see Appendix D.) While *Science of Campaigns* offers useful insights into how Chinese military strategists conceptualize the use of cruise missiles in various scenarios the PLA might face, the book raises as many questions as it answers. It appears to be aspirational in many respects, advocating a wide variety of sophisticated and simultaneous actions on the part of the PLA but not explaining how these might be accomplished or what their relative prioritization is.¹¹ The issue of how the PLA plans to coordinate joint operations is particularly uncertain as it appears to have made relatively slow progress in this area. For instance, *Science of Campaigns* states that the Second Artillery Corps has “conventional missile and cruise missile units” but does not explain how these cruise missile forces might be coordinated with those of the PLAN and PLAAF or others.¹² To probe how the PLA(N) might actually fulfill these somewhat generalized and potentially aspirational missions in the future, the following sections will analyze Chinese tactical research and the performance parameters and limitations of potential launch platforms.

Research on Tactical Employment

Considerable research is underway to help the PLA determine how best to employ cruise missiles. In an October 2004 study on attacking CSGs, PLAN researchers offered three intuitive and tactically significant methods to “win the high tech local conflict in the future.”¹³ In addition to exploiting air defense sensor “blind spots,” the navy study highlights the importance of reducing enemy warning/reaction time as well as using ASCM stealth and supersonic speed to decrease enemy detection distances.¹⁴ Some critics

may argue that PLAN employment of these tactics is a case of Beijing copying Western tactics. Joining battle in this way, however, could present significant challenges to U.S. CSG forces and place considerable pressure on the Aegis Weapon System.

The Beijing University of Aeronautics and Astronautics claims to have conducted extensive modeling and simulations studies regarding ASCM penetration against integrated air defenses. In order to attack “important targets on the sea” effectively, random altitude and maneuver penetration strategies were simulated, resulting in alleged probabilities of effectiveness in a range of 83 percent to 99 percent.¹⁵ With implied and specific approaches to Aegis penetration such as “snake” (side-to-side) and “porpoise” (up-and-down) maneuvers, Chinese maritime warfare scientists have demonstrated considerable sophistication. As early as June 2002, researchers from the Dalian Naval Academy examined the prospects for overcoming an *Arleigh Burke*-class destroyer’s capability to defeat an ASCM saturation attack.¹⁶ Another source emphasizes that penetrating a ship’s missile defenses involves avoiding enemy radar detection, infrared detection, and the enemy’s detection of the electric wave when the missile is fired.¹⁷

Chinese analysts are studying how to use antiship missiles to maximum effect. “In future high tech battles at sea, precision attacks using intermediate and long range antiship missiles will be the fundamental tactic for attacking sea targets,” writes a Dalian Naval Academy graduate student and his military colleague. “In future high tech regional sea battles, to gain control over combat at sea, minimize our side’s losses, improve survivability of anti-ship missile launch platforms, and reduce enemy countermeasure effectiveness against our anti-ship missiles, we must launch the missile immediately after the target is detected (or the target is reported by guided forces), as well as at the longest range possible.”¹⁸ At the same time, recognizing the increasing role of ASCMs in future warfare, Chinese analysts also suggest that the PLAN needs to enhance its defense against them. In that context, the navy has also made significant progress in recent years though it faces the same physics-based limitations as any military.¹⁹

Researchers supporting PLAN tactical maturation have also dissected U.S. Tactical Digital Information Link (TADIL) technology with the aim of developing reconnaissance and jamming methodologies.²⁰ In addition to possibly attempting to exploit or deny U.S. TADIL transmissions, China may well be working to develop its own TADIL capabilities.²¹

Current discussions in the context of a Taiwan conflict often center on Aegis-defended aircraft carriers. Since Taiwan has no aircraft carriers, the PLAN clearly expects to be engaged by U.S. CSG forces and is aggressively experimenting and training for such an engagement.²² Chinese assessments of the PLAN’s own capabilities must be weighed carefully, considering China’s history of embellishing facts concerning its military capability. But widespread and often compelling claims in support of enhanced long-range sea strike proficiency and lethality merit thorough investigation.

Training for “Actual War”

A wide range of Western and Chinese scholars suggest that while PLA hardware is indeed improving rapidly, the software of human capability and training needed to deploy and operate it effectively in actual combat continues to lag well behind. Yet, as in so many other areas, training has intensified over the past few years and reached a higher level of diversity and sophistication. This pattern appears to extend to Chinese cruise missile operations.

Recent exercises have involved land, air, surface, and undersea platforms. The nature and sophistication of cruise missile exercises varies with the firing platform being tested and the service responsible for that platform. Even now, PLA exercises using SAMs and other countermeasures against incoming enemy cruise missiles, as part of the “three attacks and three defenses,” appear in many respects to be more numerous²³ than exercises to practice the offensive use of Chinese cruise missiles. Both the Second Artillery and the PLAAF have missiles for this purpose. Moreover, PLAN surface ships have air defense missiles. Yet the latter type of exercise appears to be rising rapidly while the former is holding relatively steady, albeit at a higher operational tempo. Increased training in striking maritime targets appears to be a priority.

As a general pattern, GLCMs have long been deployed in a fairly effective and sophisticated manner and are now increasingly mobile and difficult to detect prior to launch.²⁴ Some are controlled by the Second Artillery Corps and some by the PLAN.²⁵ High caliber personnel are selected for important units; the Second Artillery newspaper *Rocket Force News*, in a possible reference to a DH-10 brigade, lavished praise on the PLA’s “first land-based cruise missile contingent in a parade formation” during China’s October 1, 2009, anniversary in Beijing.²⁶ Launch exercises stress “actual combat conditions.” In a June 2009 exercise lasting more than a month, a Second Artillery cruise missile brigade engaged in the increasingly common practice of moving across regions before maneuvering to a comprehensive training site a substantial distance away. The brigade then used mobile launchers, faced enemy special forces, and made emergency repairs.²⁷ A September 2009 exercise “sank a large ‘enemy’ transportation ship and badly damaged a destroyer and a frigate” from mobile PLAN South Sea Fleet launchers with “outstanding cross-country capability” operating in a remote, forested mountain area in Guangdong Province.²⁸ Like China’s other services, the Second Artillery employs simulations for a growing portion of its training, although experts at the Second Artillery Command College acknowledge that they have not yet reached U.S. standards in that regard.²⁹

PLAN accounts stress the importance of realistic training and suggest recent increases in long-range sea strike training. Surface vessels regularly engage in “missile live-fire” exercises³⁰ including against each other.³¹ Confrontational training has involved the simulated firing of missiles at enemy ships;³² destroyer loadouts can include ASCMs.³³

China Military Online reports, “In view of its future operational tasks, a frigate group . . . has intensified its efforts to . . . raise the hitting accuracy of missiles under the complicated sea conditions.”³⁴ PLAN destroyers operating in the South China Sea have conducted “training in a real war setting in an effort to build up the troops’ capability of accurate hitting against attacking targets.”³⁵ In the same exercise period, the PLAN declared several aviation breakthroughs during training in “long-distance blue-sea strike . . . and night zero-feet flight at sea.”³⁶ A 2009 exercise appeared to involve *Houbei* Type 022 missile catamarans firing ASCMs; interestingly, “the helmsman” had to “use the rudder cleverly to minimize the rocking of the boat,” which could compromise “missile inertial aiming,” and the “launch station chief” had to make maximum use of this opportunity to complete inertial aiming.³⁷

PLAN submarines practice firing cruise missiles regularly.³⁸ According to ONI, “As part of integrated opposed force play, exercises stress the use of the PLA(N)’s newest antiship cruise missiles by ships and submarines. . . .”³⁹ In one 2008 exercise, North Sea Fleet submarine 328 mounted a missile attack against enemy surface vessels under difficult conditions.⁴⁰ It is unclear how sophisticated and realistic are firing training for SCLMs or how advanced and effective are the C4ISR to cue their targeting, but their primary launch platforms, namely diesel submarines, are increasingly quiet and some extremely so.⁴¹ In one 2009 exercise held by the South Sea Fleet, sonar personnel on submarine 312 detected an “enemy” surface ship, rapidly “compute[d] the position, distance, and the direction and speed of sail the target,” and enabled a friendly surface ship to fire a missile over the horizon to hit the ship 5 minutes and 27 seconds after the transmission of its position.⁴²

Aircraft have historically lagged most significantly as launch platforms, but China’s recent aircraft acquisitions and a new generation of pilots flying longer hours in training are making a difference even there. PLAN Aviation bomber regiments have trained to conduct multi-axes, multisalvo, long-range sea strikes with the South Sea Fleet. In one such exercise, a total of eight aircraft were claimed to have operated in “complicated weather conditions” during “complex electromagnetic interference” while coordinating missile attack preplans with air force and army units, and all against “enemy” targets at sea “in batches and from different directions.”⁴³ South Sea Fleet training has not omitted other important “needs of the actual war” including logistics support under complex maritime conditions.⁴⁴ The PLAN’s East Sea Fleet also recently paid “great attention to honing its operational support capability in line with the criteria of real operation.”⁴⁵

For several years now, both PLAN Aviation and the PLAAF have been running exercises that involve cruise missile firing over water including at night⁴⁶ and against surface vessels.⁴⁷ PLAN pilots conduct live fire exercises.⁴⁸ Aircraft involved include H-6 bombers and JH-7A fighter-bombers. “Emergency missile loading exercises,” which may well in-

clude cruise missiles, occur regularly.⁴⁹ Some exercises involve “practice cruise missiles” (训练航弹). In a possible reference to practicing using the DH-10 LACM, one aviation division stationed opposite Taiwan in 2008 practiced precision “long-range air-to-ground strikes” during nighttime “toward a distant sea area” using a “particular [new] type of air-to-ground guided missile.”⁵⁰ That same year, a PLAAF aviation regiment “achieved a hit rate of at least 87% in several dozen precise attacks on radar and missile sites and [moving] ships at sea” despite electronic interference and attacks from opposition forces.⁵¹ In sum, the potential for PLAAF and PLAN aircraft successfully striking U.S. CSG forces at night from significant stand-off ranges is difficult to foresee in the near term. Yet training seems to be underway to attain such a capability.

While cruise missiles remain tied to limitations in the platforms from which they are fired, the PLA is moving toward an ability to coordinate and launch fairly complex strikes against moving sea targets. The human element may still be a limiting factor and remains difficult to assess, but the limitations are growing smaller by the day.

Cruise Missile Defenses

Despite progress in offensive cruise missile capabilities, China views itself as vulnerable to cruise missile attack. The PLAAF also controls the majority of ground-based air defenses, which operate under the 1999 concept of the new “Three Attacks” (against stealth aircraft, cruise missiles, and armed helicopters) and “Three Defenses” (against precision strikes, electronic jamming, and electronic reconnaissance and surveillance).⁵² In addition to its seven military-region air forces, 13 deputy corps-level and division leader-level command posts, and multiple academies and research institutes, the PLAAF has a SAM and AAA corps and three airborne divisions assigned to 15th Airborne Army.⁵³ According to DOD, the PLAAF “has continued expanding its inventory of long-range, advanced SAM systems and now possesses one of the largest such forces in the world.”⁵⁴ It has also received multiple battalions of upgraded Russian S-300/SA-20 PMU-2 long-range (200 km) SAM systems since 2006. Russia’s most modern SAM system available for export, the SA-20 PMU-2, offers Taiwan Strait coverage and reportedly provides limited ballistic- and cruise-missile defense capabilities.⁵⁵ China has also introduced the indigenously designed HQ-9.

As with other areas of operational capabilities integration, critical uncertainties remain regarding cruise missile defense. It is still unclear, for instance, how the PLAAF and the PLAN deconflict the operations of aircraft and SAMs working in the same airspace, how often they actually practice these operations, and how well deconfliction would work during actual combat. PLAAF writings suggest that SAMs and aircraft conduct “combined-arms training” but this is actually what the U.S. military would call opposition

force training, with the aircraft attacking areas the SAMs are defending. It is difficult to find documentation of SAMs and aircraft working together against attacking aircraft. It is unclear whether PLAAF and Naval Aviation aircraft actually fly, or even can fly, in the same airspace covered by the various services' SAMs or how they will coordinate so the SAMs do not shoot down friendly aircraft. For instance, will the fighters fly out and meet enemy aircraft with SAMs covering them, or will the aircraft be the last line of defense in case the SAMs do not shoot down the enemy aircraft? Further research is needed.

While it still has significant vulnerabilities against cruise missiles, China is addressing them. Early warning by means of improved surveillance and precision tracking radars against low radar cross-section targets would be among the most important required capabilities in developing anti-cruise missile defenses, especially against LACMs. Effective combat identification to distinguish friendly aircraft from enemy cruise missiles is also important.⁵⁶ Because ground-based radars are horizon-limited,⁵⁷ a true defense-in-depth strategy would require airborne platforms that could detect cruise missiles out to several hundred kilometers. That kind of defense-in-depth would permit multiple shots against low-flying, low-cross-section cruise missiles. Defense-in-depth against large raid size LACM attacks cannot be accomplished satisfactorily without highly sophisticated and preferably large airborne AESA radars⁵⁸ linked to adequate inventories of interceptors with sensors that can cope with low radar cross-section targets. AESA-equipped long-range fighters armed with advanced air-to-air missiles would complement such a cruise missile defense architecture. Because defending against ASCMs is comparatively easier, China is likely to achieve more success at first in developing cruise missile defenses against cruise missile attacks at sea than over land.

Chinese analysts note that the U.S. Army has for some time engaged in R&D on possible cruise missile defense systems.⁵⁹ One media report quotes the U.S. Air Force as stating that it "can send . . . cruise missiles to any portion of the Asian mainland within a few hours."⁶⁰ Personnel from the Nanjing Military Region Headquarters Department General Office worry that in the event of a conflict, "enemy aircraft carrier battle groups may move to some important strait channels and nearby sea areas, using cruise missiles and other long-range precision guided weapons with direct attack ammunition to blockade our first- and second-line airports, military bases, and large and medium sized cities in deep rear areas from the seas, thus placing unprecedented pressure on our counter-blockade operation."⁶¹ Large cities relatively near the coast, such as Beijing and Nanjing, reportedly have air defenses to counter cruise missiles and other weapons, but their effectiveness is questionable.⁶² Researchers at Shijiajuang Ordnance Engineering Academy fret that "although most of China's national defense cave depots are located in remote mountains, under the threat of modern precision guided weapons, especially

cruise missiles, these conventional measures of security, camouflage, and concealment are already not up to the task of protecting against attacks.”⁶³

While analysts point to progress in the PLAN’s capability to defend against ASCM attacks, they also recognize the difficulty in general in defending against cruise missiles. One PLAN analyst argued in July 2004 that “given the forces available today, China cannot adequately defend its fleet from air attack in the modern air threat environment.”⁶⁴ Of course, this assessment was published before the PLAN launched the highly capable *Luyang II* area air defense destroyer, the *Luzhou* destroyer, and the *Jiangkai II* air defense frigate. More recently, researchers at the PLA Navy Aviation Engineering Academy have studied the efficiency of ship-to-air missiles at low altitude with close examination of U.S. defense systems.⁶⁵

China has acquired potent land- and sea-based missile defense systems. According to DOD’s 2011 report, “China’s existing long-range advanced SAM inventory offers limited capability against ballistic missiles, but advertises a capability against cruise missiles. The SA-10 was originally designed to counter low-flying cruise missiles, a capability enhanced in the later model SA-20 systems. . . . China’s HQ-9 long-range SAM system is also advertised (through its export variant FD-2000) to protect against low-altitude cruise missiles and is expected to have a limited capability to provide point defense against tactical ballistic missiles with ranges up to 500 km.”⁶⁶ Still, without high-quality AESA radars deployed on airborne platforms, such interceptors will only be capable of limited point defense.

It appears now as if the PLAN is working to address remaining cruise missile defense problems and has made progress. As a recent doctrinal publication states, during “anti-air raid,” or air defense, campaigns, “in order to provide early warning for ballistic and cruise missile attack, we should . . . form a strategic intelligence early warning system based on air defense early warning and space defense early warning.”⁶⁷ One study warns that “the effect of land and sea clutter is . . . an important factor in reducing the probability of detection and identification.”⁶⁸ Another article carefully studies the U.S. Tomahawk’s capabilities,⁶⁹ characteristics, and its use in the Gulf Wars, ultimately concluding that the PLA needs to use combined “soft” and “hard” countermeasures to defend against a cruise missile attack.⁷⁰

Air defense brigades are developing new tactics to defeat cruise missiles and practice employing them under increasingly realistic conditions—and, if they have SA-20s, new air defense systems that can shoot them down. One approach could be the electronic jamming of enemy cruise missiles to reduce their ability to accomplish precision strike missions.⁷¹ Researchers at the PLAAF Engineering Academy’s Missile Institute have examined measures of effectiveness presented by the U.S. Weapon System Effectiveness Industry Advisory Committee and developed their own models to examine the efficacy

of terminal aerial defense missiles against cruise missiles.⁷² A doctoral student at Dalian Naval Academy has proposed improved methods for decisionmaking for defending against ASCM attack.⁷³

Greater knowledge of how to maximize the effectiveness of defense systems (particularly vis-à-vis U.S. systems) may also facilitate a more formidable offense. One way to defend against an air attack is to “shoot the archer.” In advocating forward deployment of frigates to provide an air defense perimeter for the PLAN, one article states, “In the match-up between the firing range of the spear and the shield, the shield has always been at the inferior position, and this is the problem that causes all nations’ navies to feel that they are seated in an unsafe position.” Today, “even if a navy possesses an aircraft carrier battle group with ship-borne fighter planes as a long-range interception method, the ship-borne area air defense missile has already completely [fallen away] as a terminal interception tool for fighting anti-ship missiles.”⁷⁴ In future conflicts, ASCM saturation attacks may prevent an opponent’s air threat from ever materializing, particularly if the ASCM raid comes as a surprise to the recipient.

At the same time, effective defenses enable better offense. Chinese analysts worry that their cruise missiles are vulnerable to jamming, interception, and other defeating methods. They observe with interest the U.S. development of a cruise missile defense (CMD) system.⁷⁵ For this and other reasons, researchers at the Second Artillery Engineering College state, “for China’s new generation ‘assassin’s mace’ weapons, the question of how to effectively increase the defense penetration capability of cruise missiles has become increasingly a focal point of attention.”⁷⁶

Undermining Cruise Missile Defenses

Chinese researchers claim that China is developing a wide variety of means to defeat cruise missile defenses, some of which are already in use. Researchers at Northwestern Polytechnic University advocate reducing the ability of long-range ultra-high frequency (UHF) early warning radar systems such as PavePaws to detect incoming cruise missiles and degrading the ability of Patriot-3 PAC-3 air/missile defense systems to acquire and engage them.⁷⁷ Specific means addressed include reducing the missile’s radar cross section, engaging in electronic jamming, and increasing cruising speed.⁷⁸ “China is . . . emphasizing research on conventional contour and stealth material methods . . . [and] stressing the development of new concepts in stealth technology” such as “using high performance absorptive materials.” Much work remains to be done to overcome costs and performance losses, but already progress has been made in such areas as theoretical research concerning plasma stealth technology.⁷⁹ Radar jamming is advocated for both defensive⁸⁰ and offensive purposes. One approach under discussion is using aircraft and

missile attacks as well as electronic jamming to reduce AWACS detection range and then employing aircraft and missiles to attack.⁸¹ The author adds that China began research on high-power microwave weapons in the early 1990s. While a gap of “four or five magnitudes” remains “between available devices and what is needed to get results,” China is proceeding gradually with the development of ground-to-air, high-power jammers. “China will first consider the requirement to jam high-power radars on AWACS” leaving “jamming satellite equipment” as “the second step for making strides into ‘high-power microwave weapons development.’”⁸² Experts at the Naval Aeronautical Engineering Academy and Dalian Naval Academy have studied how to assess the operational effectiveness of ASCM defense systems in atmospheric ducting conditions.⁸³ It must be emphasized that this work tends to be either theoretical research about potential practicality or investigations dependent on major technological breakthroughs; nevertheless, the research offers indications of China’s cruise missile development trajectory.

Possible Future Directions

What are likely future trends in PRC cruise missile development? In addition to incremental improvements, gains from adapting existing missile systems to new platforms (for example, creating an air-launched variant of the DH-10) and to new targets (for example, creating an antiship variant of the DH-10) are likely. Researchers at Nanjing Army Command College project that “the trend in anti-ship missile development will be toward stealth, high velocity, and high maneuverability. Ship-to-ship missiles will have long-range over-the-horizon attack and coastal and inland target attack capability.”⁸⁴ Mastery of real time targeting could help the PLA to achieve significant operational breakthroughs. ONI summarizes the larger trends in Chinese ASCM development:

China continues to focus on developing ASCM capabilities with the emphasis on faster, longer range and more flexible missiles with improved electronic systems and terminal evasion maneuvers. Future ASCMs are expected to continue to advance seeker capabilities including the expanded use of millimeter wave seekers^[85] and the possible use of coherent radar seekers that allow enhanced countermeasure discrimination. The continuing development of ASCMs with improved design features such as supersonic speed, evasive maneuvers, and advanced terminal seekers will present ongoing challenges to navies throughout the region.⁸⁶

Supersonic Speeds

Chinese experts emphasize that despite rapid progress in cruise missile programs and the fact that “supersonic ASCMs will undergo tremendous development” in the next two or three decades, supersonic ASCMs present many challenges that are not easy to overcome. These include such areas as more complicated R&D, size and weight, anti-interference, and stealth. Moreover, future combat will involve more than just one type of weapon or unit fighting, thereby requiring ASCMs to have multipurpose functions.⁸⁷

Longer Ranges

China is exploring the conversion of LACMs, which have ranges longer than their extant ASCMs, to attack ships at sea. If this is achieved, aircraft could fire cruise missiles from outside the SAM envelope of U.S. warships. China has already fielded an LACM, the YJ-63, with a 200 km range. For this LACM to be adapted to hit a moving ship, its midcourse programming would have to be compressed into a reasonable timeframe, and it would have to arrive within a small seeker “basket” containing the moving ship—both demanding tasks. Finally, a terminal guidance system would have to guide the missile to the target. Assuming this all works as planned, the missile would have to survive U.S. Navy terminal defenses, which have been recently improved with the addition of a new airborne platform and greatly improved terminal interceptors.⁸⁸

Indications exist that an antiship variant of the DH-10 LACM with a range of 3,000 km could be at least in the early phase of an R&D program. As far back as 2002, CASIC Third Academy designers presented a case in authoritative industry journals that Third Academy cruise missiles could be adjusted to fulfill the requirements of longer-range precision strikes—at least out to 8,000 km—against a broad range of targets including ships at sea.⁸⁹ The analysis compared the operational effectiveness of cruise and ballistic missiles, presumably as part of a business campaign to capture the lead for a strategic counter-aircraft carrier program. However, to ensure the ability to penetrate maritime defenses, designers highlight the need for new propulsion systems, reduction of the missile’s radar cross section, increased maneuverability, and even exploiting advantages in near space—a daunting array of technological breakthroughs.⁹⁰

Achieving such a series of breakthroughs would certainly improve PLA access denial capabilities. However, there are significant challenges. Hitting a fixed target is different from hitting a moving target, requiring different guidance and seekers. ASCMs sea skim to their targets, which are metal objects on a flat surface, water. LACMs fly comparatively longer distances over land, with varied terrain features requiring sophisticated mission planning systems; when they arrive near their fixed targets, they either fly into the target using GPS-aided INS, employ a terminal sensor to compare the target to an onboard

image, or use an electro-optical sensor. As researchers at Tianjin's Jinhang Institute of Technical Physics point out, for LACMs, "the background is the ground, which is very complex. In most cases, the targets do not have artificial heat sources. They coexist with the background in a natural environment, and the object contrast is relatively low."⁹¹ The challenge for adapting a LACM to hit a moving object is timing. ASCMs are not preprogrammed in the same way as LACMs. Surveillance and tracking systems tell precisely where the ship is, but by the time the data are passed to the LACM user who has to program the missile (which can take considerable time), the ship has moved.⁹²

Perhaps building on successes in its R&D on extended range cruise missiles, China's defense R&D community also appears to be investing in conceptual design work on hypersonic cruise vehicles (HCV).⁹³ As an example, the U.S. hypersonic cruise vehicle program is a USAF/Defense Advanced Research Projects Agency (DARPA) effort to develop an air-breathing platform that could deliver a 5,000 kg payload 17,000 km in 2 hours at speeds of up to Mach 6 and near-space altitudes. One study in particular outlined the results of modeling and simulation of a scramjet-powered vehicle with a range of between 1,000 and 2,000 km, flying toward its target at an altitude of between 25 and 30 km and speed of Mach 6.⁹⁴ Another focused on a hypersonic cruise vehicle adopting a skipping trajectory with an upper altitude of 60 km and a lower altitude of 30 km.⁹⁵ In addition to addressing specific guidance, navigation, and control issues, aerospace engineers have also been carrying out basic research in an air-turbo rocket (ATR) propulsion system, an airbreathing system that combines elements from both turbojets and rocket engines. Simulations validated one design that operates at speeds up to Mach 4 and altitudes of up to 11 km.⁹⁶

Finally, there is the age-old issue of offense vs. defense, which Chinese analysts follow closely and which appears to inform the PLA's development and prioritization of weapons systems. There is a constant arms race between the ever-advancing defense systems of surface vessels and the cruise missiles that seek to defeat them. A senior captain from the PLAN Armaments Department emphasizes that ASCMs must constantly be adjusted to address changes in the numbers and characteristics of targets, their mission, and the battle environment.⁹⁷ Researchers at Northwestern Polytechnic University's School of Electronic Information seek to optimize cruise missile penetration altitude for maximum "combat efficiency,"⁹⁸ as do engineers at CASIC's Third Academy.⁹⁹ Researchers from Wuhan Naval Engineering University and Northwestern Polytechnic University believe that future cruise missiles will need to have greater range, higher speed, enhanced maneuverability, "multiple types of trajectory control," and "intelligent control guidance." Moreover, these missiles will combine subsonic and supersonic flight stages: "subsonic missiles can meet the need for long ranges, and supersonic missiles can greatly improve the probability of defense penetration."¹⁰⁰ In pursuing such capabilities, the PLA may be able to minimize its vulnerabilities while maximizing its offensive potential.

Tactical Nuclear Delivery? A Subject of Speculation

The Soviet navy heavily emphasized the employment of nuclear-armed cruise missiles against U.S. carrier strike groups during the Cold War. Both the United States and Soviet Union/Russia developed and deployed such missiles, but they are now out of, or headed out of, their respective inventories. Several American analysts have speculated that China might pursue nuclear cruise missiles in the future. Despite the absence of major technological barriers, to date no concrete evidence suggests that this pursuit is happening. China would face several nontechnological barriers in developing and deploying nuclear-armed cruise missiles, which would raise significant command and control issues, be inconsistent with current nuclear doctrine, and cause undesirable international reactions. Indeed, an article by the Chinese Communist Party Committee of the People's Liberation Army (PLA) Air Force suggests that "strategic air forces in various nations are equipped with . . . nuclear cruise missiles, but no nation dares to easily cross that threshold, and the main mission of nuclear weapons is for strategic deterrence."¹ Yet the possibility cannot be entirely ruled out. A U.S. analyst, for instance, hints at the possibility of Chinese tactical nuclear weapons: "new ballistic and air- and ground-launched cruise missiles will give Beijing a more survivable and flexible nuclear force."² Rear Admiral Michael McDevitt, USN (Ret.), goes so far as to assess that the PLA Navy (PLAN) is likely already "arm[ing] nuclear attack submarines with nuclear-tipped cruise missiles."³

While this study did not uncover any evidence of the PLA actually possessing such substrategic nuclear weapons, the Soviet navy has clearly influenced the PLAN. Reflecting on today's Russian navy, the PLAN publication *Modern Navy* [当代海军] notes that the *Akula*-class nuclear-powered general-purpose attack submarine Gepard (launched in 2001) can carry 24 nuclear-armed cruise missiles.⁴ There is some evidence that at least one Chinese researcher has explored the advantages of nuclear-tipped cruise missiles and the options available to increase lethality. According to Senior Captain Liu Yang, a PLAN officer at the Wuhan Office of the Naval Armaments Department, all options seem to be on the table. For the "special anti-aircraft carrier mission," which is difficult for regular antiship cruise missiles, a "new type" cruise missile must be developed whose "warhead system" has increased explosiveness. Liu outlines three major potential courses of action. Using previous cruise missiles as a foundation, a "low-weight nuclear burst warhead" (小当量的核爆战斗部), a "fuel air explosive warhead" (燃气空气战斗部), or "another special type of warhead with even greater power to inflict casualties (其它具备更大杀伤能力的特种战斗部) . . . can meet the requirements for attacking an aircraft carrier."⁵ Liu's affiliation, location at Wuhan (a major PLAN weapons testing community), and citation of only Chinese sources (as opposed to merely summarizing Western studies) suggest that these ideas may be under serious consideration and may even have moved beyond

the theoretical stage.⁶ Factors that would seem to militate against Chinese development of nuclear cruise missiles include perceptions that such weapons are provocative and China's historical desire to maintain centralized control of all nuclear weapons. To date, there is no evidence that China has nuclear-tipped cruise missiles in its inventory or is developing them.

Notes

¹ Dong Wenxian [董文先], "Integration of Offense and Defense: The Basic Characteristics of Modernized Strategic Air Force" [攻防一体: 战略空军的基本特征], *Air Force News*, February 16, 2008, 2.

² Clark A. Murdock, "DOD and the Nuclear Mission," *Joint Force Quarterly* (4th Quarter 2008), 14. According to arms control expert Jeffrey Lewis, Murdock's paraphrase is inaccurate, and he does not demonstrate that China will develop nuclear cruise missiles; it would still have to arm them with nuclear weapons. The report Murdock cites states elsewhere that Chinese cruise missiles are conventionally armed (at least for now). There is some doubt that China yield-tested a warhead before 1996. Various declassified assessments from the 1990s discuss how many tests China might need to finish a cruise missile warhead. In September 1993, the Central Intelligence Agency assessed that China would need seven tests (or "two to eight") to complete development of warheads for ballistic missiles under development and some safety enhancements. (China conducted seven before signing the treaty, which was not, Lewis believes, an accident.) It was "almost certain" that the warhead for a nuclear armed DF-11 had been completed. The question was whether a future cruise missile nuclear warhead would repurpose an existing design (such as a DF-11 warhead) or require additional tests. No additional tests took place and the seven seem very much linked to the DF-31 program "and maybe a little science at the end." Lewis adds, "Today, China doesn't seem to have nuclear-armed SRBMs [short-range ballistic missiles]. So that raises the question: Which tests in China's inventory were for a relatively small nuclear warhead? I honestly have trouble coming up with plausible candidates, other than the neutron bomb tests in the early 1980s, and my research suggests those were more driven by a Central Committee desire to match the U.S. than linked to a specific weapons system. I don't think they resulted in a warhead certified for deployment. I suppose the summary is this: the *Chinese Military Power* report says the SRBMs and cruise missiles are conventionally-armed. That makes sense given the growing emphasis on conventional missiles. The Chinese said the cruise missiles in the October 1, 2009, military parade were conventionally-armed. (They made quite clear that the DF-31/31A was nuclear armed.) I don't see much evidence that they developed a cruise missile warhead in the testing program, but you might be able to convince me a couple of the last few tests were for that purpose. But the burden of proof would be on the person to show that the Chinese developed the warhead." At the same time, Lewis concludes, "I am sort of surprised Chinese cruise missiles aren't nuclear, to be honest. Not sure if it will last." Telephone and email interviews with Jeffrey Lewis, December 2009. See also <www.armscontrolwonk.com/1945/dh-10>.

³ Michael McDewitt, "The Strategic and Operational Context Driving PLA Navy Building," in *Right-Sizing the People's Liberation Army: Exploring the Contours of China's Military*, ed. Roy Kamphausen and Andrew Scobell, 513 (Carlisle, PA: Army War College, 2007).

⁴ Hai Sheng [海生], "Russia's 'Gepard' Heavy Fist Launches an Attack" [俄罗斯'猎豹'重拳出击], *Modern Navy* [当代海军] 98, no. 11 (2001), 6.

⁵ Alternatively, a new type of specialized anticarrier cruise missile can be developed using mature technology. For attacking small, fast surface targets, Liu advocates development of a cruise missile with a small body, light load, and strong maneuverability. For use in electronic warfare, he calls for three types: a missile that can attack an enemy radar after detecting its "electromagnetic radiation source" (电磁辐射源), a missile with a small, light warhead that can home in on and jam enemy air defense radars while being itself resistant to interference, and "an electronic warfare missile that delivers an electromagnetic pulse [装载电磁脉冲战斗部的电子战导弹]" to "paralyze" enemy shipboard electronics.

⁶ Senior Captain Liu Yang, PLAN [刘杨大校], Naval Armaments Department, Wuhan Office [海军装备部武汉局], "The Requirements of Special Anti-Ship Cruise Missiles from the Perspective of Surface Ship Development" [从水面舰艇的发展看特种反舰导弹需要], *Winged Missiles Journal* [飞航导弹], no. 6 (2008), 43.

Implications of PRC Cruise Missiles for the United States and Regional Allies

China is clearly placing a high priority on cruise missile development and deployment. The addition of capable cruise missiles to the PLA and its ability to deliver them by land-, air-, and sea-based platforms offers a significant increase in offensive strike capabilities. The following are some preliminary implications with a focus on the maritime dimension.

A2/AD Capability

With its prolific development and acquisition of increasingly advanced cruise missiles, the PLA is rapidly augmenting what the U.S. military terms its “A2/AD” capability, and what it terms “counter-intervention” capability—essentially two sides of the same coin, depending on one’s perspective.¹⁰¹ Terminology aside, this ongoing enhancement of PLA capabilities is especially relevant for even advanced militaries operating close to the Chinese mainland and poses an increasing asymmetric challenge to U.S. forces operating in the region. As a military platform moves closer to Chinese soil, it will move within range of more Chinese missiles. Beijing will likely call on the PLAN to defend China’s interests throughout its recognized and disputed exclusive economic zones and to “exert some form of counter-power against U.S. forces,” particularly with respect to Beijing’s internal dispute with Taipei.¹⁰² The implications for U.S. CSGs are clear: they would not be able to operate with impunity in areas close to China in certain contingencies and might have to maneuver to avoid danger.

Land Strike Capability

While ASCMs threaten U.S. surface forces, LACMs offer growing land strike capability. At present, this capacity is directed primarily against Taiwan, but the growing ranges of China’s land and air-based launch platforms can also threaten Japan, Korea, the Philippines, and the U.S. territory of Guam as well as several other locations.

Expeditionary Strike Capability

PLAN expeditionary forces will likely have robust cruise missile strike capabilities in the future, but the implications for their ability to “go out” in high-intensity contested conditions are unclear. In theory, Chinese surface action groups and submarines armed with cruise missiles would have a potent capability to attack, threaten, or deter other navies. However, that depends on the ability of the naval platforms carrying cruise missiles to survive in distant waters. ASCMs may be employed to deny adversary use of choke

points, but they cannot ensure the safety of Chinese ships against attacks by submarines or sophisticated adversary ASCMs. What ASCMs buy is area denial, not assured access. Moreover, for the foreseeable future, China is likely to have a limited number of long-range platforms, thereby imposing a distance gradient on high intensity use.

Cruise Missile Ratios

DOD transformation assumes that by shaping the nature of military competition in U.S. favor, or “overmatch,” rivals will continually lag in a demanding security environment. What if this is a false assumption? In other words, China may be choosing to compete in a traditional or conventional maritime environment in which transformed U.S. forces are structured and equipped in a significantly different way. As analyst Mark Stokes has reported, some Chinese believe that, due to the low cost of developing, deploying, and maintaining LACMs, cruise missiles possess a 9:1 cost advantage over the expense of defending against them.¹⁰³ The far more important—and difficult to estimate—ratio is that of PLA ASCMs to U.S. Navy defense systems. Numbers alone will not determine effectiveness; concept of operations and ability to employ cruise missiles effectively in actual operational conditions will be the true determinants of capability. Even without precise calculations, however, it appears that China’s increasing ASCM inventory has increasing potential to saturate U.S. Navy defenses. This is clearly the goal of China’s much heavier emphasis on cruise missiles, and it appears to be informed by an assumption that quantity can defeat quality. Saturation is an obvious tactic for China to use based on its capabilities and emphasis on defensive systems. PLAN ASCM weapon training, production, and delivery platform modernization continues to progress rapidly. Scenarios involving hostile engagement between PLAN and U.S. CSG forces could be quite costly to the latter due to the sheer volume of potential ASCM saturation attacks.

Asymmetric Challenges

Washington and Beijing have chosen to approach the problem of antiship and land attack in different ways. The United States has pursued carrier-based aviation as its primary strike capability with some carrier aircraft carrying AGM-84 Harpoon and AGM-65 Maverick missiles. China has placed much greater emphasis on cruise missiles relative to aviation. The missiles themselves reveal different philosophical approaches. The U.S. Harpoon is relatively slow at 850 km/h, but its homing capabilities are extremely sophisticated. Chinese missiles tend to use the Soviet/Russian approach of high-speed, low-altitude attack. Most of China’s cruise missile platforms are based along its coast and are augmented by an increasing though limited use of aircraft as launch platforms. The

United States thus has forces that can project power wherever a CSG can go while China is able to operate only in a more constrained space.

China's defense industry is currently working two parallel paths: production of indigenous advanced weapon systems, and accumulation of 1980s and 1990s ASCM technology. The latter involves a technology lag, but procurement of relatively inexpensive ASCM weapon systems may be a calculated attempt to exploit a perceived gap in U.S. military hardware. Many have argued, for instance, that to compete with the United States in a maritime conflict, the opposing side would need to approach parity in deck aviation capabilities. The assumptions supporting such an argument vis-à-vis China may no longer be valid, however. The PLAN has clearly elevated ASCM development over an organic carrier capability with the apparent goal of acquiring the capability to neutralize U.S. CSG forces through overwhelming ASCM attacks. The PLAN is thus making calculated applications of technology and asymmetry—most notably, an apparent quantitative advantage in ASCMs over relevant defenses based on U.S. naval platforms. Given that China now has a quantitative edge and the United States has a qualitative edge, it will be essential to determine how Chinese cruise missiles perform against U.S. defenses.

U.S. Response

New Chinese cruise missile capabilities have the potential to threaten the U.S. and East Asian navies. It may be argued that, although there appears to be compelling evidence of a robust PLAN ASCM capability, China's combat effectiveness in a maritime conflict has yet to be tested. But the same may be said of U.S. CSG forces in terms of their ability to defend themselves from concerted attacks. ASCMs represent a new, asymmetric challenge that must be taken seriously, and the U.S. Navy must devise appropriate countermeasures. CSG vulnerabilities, for instance, must be addressed in further research. It may be of some interest to consider the volume of saturation and Aegis-related research available in Chinese open sources, compared with an apparent void of such focused analysis on the opposing side. Experienced Aegis warriors will respect China's emerging capabilities, and they must constantly drill to counter them with discipline and tenacity. Predicting the victor in a battle of ASCM sea strikes and air defense counters depends on many factors, not the least of which may be which side simply has more operationally ready ordnance. China's new cruise missile capabilities will demand significant focus and countermeasures from the U.S. military if it is not to be confronted with new Chinese antiaccess capabilities that threaten the operation of its platforms in or near key areas of the East Asian littoral. The challenge will be to develop effective countermeasures that are also affordable and thus do not place the United States on the "wrong end" of an arms race.

Emerging Roles and Capabilities of Cruise Missiles to Contribute to a Taiwan Campaign

Chinese strategy reflects a notably strong respect for adversaries' potential strengths, which is clearly the case regarding the United States but also Taiwan. In considering how LACMs might contribute to campaign and mission objectives against Taiwan, cruise missiles should be evaluated within the context of their combined arms utility in an air and missile attack on the island. While the analysis here focuses on the contribution of LACMs, particularly as they would complement ballistic missiles in a Taiwan campaign, it is also important to note that such a major operation would include electronic and information warfare assets at a minimum. If China were prevented from obtaining air superiority, any prospective Chinese cross-Strait military campaign would be less likely to succeed. Taiwan no longer holds a decided advantage in the quality of its air forces, and it long ago lost the quantitative competition.¹ China's marked emphasis on the utility of ballistic and now LACMs should be considered within this context. Like their ballistic counterparts, cruise missiles constitute a central component of China's efforts to achieve air superiority over Taiwan.

The U.S. Pacific Fleet currently has 35 ASCM-capable combatant ships, slightly fewer than half of the PLAN inventory. Each of these U.S. guided missile cruisers and destroyers has a maximum capacity of eight ASCMs. Due to maintenance and service life limitations, however, most U.S. ships have been observed operating with only four ASCM launcher canisters. As a basis for comparison, the maximum U.S. Pacific Fleet afloat ASCM inventory is capped at 280 Harpoons—the only major ASCM in the U.S. Navy—or 40 percent of the PLAN battery. In addition to unit self-defense, these 35 U.S. combatants also have the duty of protecting five U.S. aircraft carriers.²

China has far more cruise missiles of far more varieties than the U.S. Pacific Fleet would deploy. In a hypothetical Taiwan scenario, typical U.S. CSGs might sail with three or four ASCM-capable combatants. Assuming that only a third of the PLAN surface combatant fleet would be operating in support of such a scenario against one U.S. CSG, the ratio of ASCMs on the battlefield would be at least 7:1 in favor of the PLAN. This ratio does not include the number of air and (in China's case) subsurface-launched ASCMs that might be massed during such an engagement. Factors such as weapon system readiness, reliability, load-out, firing policy, and ASCM effectiveness during saturation attacks are also omitted from this discussion. This is not to say that these factors would not influence

the outcome of an ASCM battle, of course. In any event, assuming that both PLAN and U.S. forces would apply maximum available combat power, it is difficult to imagine a situation in which a lone U.S. CSG could flip the ASCM ratio in its favor.

To be sure, this is not the only relevant metric or comparison. It is not just a question of the ASCM ratio but also of the ability to move platforms that shoot ASCMs into range of their targets. It is not so much who has more ASCMs as who can fire them at the other side first. If one side has so many they literally do not need to target, then having more than the other side is helpful. If not, then it may be irrelevant. If there are significant terminal defenses, that also might make overall inventories important, although it would be a case of one side's inventory versus the other side's defense, not a straight-on ratio of inventories.

The U.S. Navy concept of operations does not rely on saturation attacks to overcome relative backwardness, so the ratio does not need to be as large. Moreover, ASCMs are certainly not the only way to attack a potential cruise missile carrier. The United States could use air and undersea platforms to target PLAN ships that get too far out from their air defense cover. But China's increasing ability to concentrate cruise missile fires will have important implications for where the United States can and should employ CSGs.

The primary mission that ballistic and cruise missiles are likely to assume is achieving the rapid if only temporary closure of Taiwan's airfields, thereby pinning down the air force and exposing it to bombardment by aircraft.³ Missile strikes against airfield runways, airbase command and control, early warning radar facilities, and ground-based air and missile defenses would also increase Chinese aircraft effectiveness. With Taiwan's aircraft thus largely impeded from taking to the skies, Chinese aircraft could be released from air defense suppression missions, allowing them to fly higher and deeper routes with heavier payloads and concentrate on reducing Taiwan air sorties to a minimum.⁴ Mark Stokes, assistant U.S. air attaché in Beijing from 1992 to 1995, notes that Chinese strategists view missile strikes against airbase runways and taxiways as designed to "shock and paralyze air defense systems to allow a window of opportunity for follow-on PLAAF strikes and rapid achievement of air superiority."⁵

Shock and paralysis come from a high volume of accurate fire in a short time.⁶ This concept undoubtedly explains the rapid growth of the PLA Second Artillery as well as qualitative improvements in PLAAF attack capabilities. China's SRBM force grew from a single regimental-size unit to seven brigades by 2008, including five controlled by the Second Artillery and two directly subordinate to PLA ground forces, one in the Nanjing Military Region (MR), and another in the Guangzhou MR.⁷ This configuration may have changed more recently. According to an April 2011 assessment by Mark Stokes, "there are indications that two tactical missile brigades under the PLA Army have transferred to the Second Artillery."⁸ By December 2010, China's arsenal consisted of 1,000 to 1,200 solid

propellant, road-mobile SRBMs, all deployed opposite Taiwan.⁹ According to DOD, this includes 350–400 CSS-6 SRBMs (with 90–110 launchers)¹⁰ and 700–750 CSS-7 SRBMs¹¹ (with 120–140 launchers). More recently, a Taiwanese media report cites the Taiwan Ministry of National Defense (MND) “China Military Power Report 2012” as claiming that the number of Second Artillery ballistic and cruise missiles aimed at Taiwan has increased from 1,400 in 2011 to 1,600 in 2012. An increasing number of these missiles are outfitted with advanced GPS to enhance precision. DF-16 medium-range ballistic missiles (MRBMs) have reportedly been deployed in small numbers.¹²

As for LACMs, the 2009 DOD report estimates that by December 2009 China had deployed 200–500 DH-10 LACMs and 45–55 launchers.¹³ In addition, an uncertain number of YJ-63 LACMs (two per H-6H medium-range bomber and possibly some 3M-14E submarine-launched LACMs on *Kilo*-class submarines) could figure into a campaign. The DH-10 is reported to be highly accurate: *Jane’s* states that it has 10 m CEP.¹⁴ Missile launchers are indeed an appropriate measure of potential effectiveness because they determine the intensity of fire within a particular unit of time during a campaign.¹⁵ This would be the case if missiles were employed to pin down Taiwan aircraft on their airfields, thereby preventing them from taking off to meet Chinese aircraft in air battles. These numbers interact sharply with the way in which Taiwan concentrates its primary aircraft at three of its eight major airbases.¹⁶ Taiwan does park some of its aircraft in hardened shelters, and a small strategic reserve¹⁷ of aircraft is hidden in hardened mountain bunkers (both visible on Google Earth). The number of China’s short-range ballistic missile launchers (200–250), complemented by DH-10 LACM launchers (40–55), more than suffices to maintain intense pulses of conventional firepower against not only airfields but also other critical target sets, such as air and missile defense sites, early warning radars, command and control facilities, and logistical storage sites.¹⁸

Saturation strikes are a logical approach for China based on operational planning considerations. Some evidence of uncertain reliability suggests that China is proceeding accordingly. Referring to LACMs as “trump card” (silver bullet) weapons, several foreign analysts report that Chinese planners have looked carefully at the complementarity of conventionally armed ballistic and cruise missiles in military campaigns.¹⁹ In examining the correct selection of weapons and warheads for particular targets, planners reportedly pay particular attention to the advantages LACMs have in precision accuracy compared with ballistic missiles. To that end, ballistic missiles are assigned against area targets, including airfield runways and taxiways, while LACMs are assigned to strike command and control targets, airfield hangars, and logistics facilities.²⁰ While the link to Chinese planners is unsupported, the logic is straightforward: LACMs have slightly better accuracy than ballistic missiles, so the latter could be problematic against command and control targets, hangars, and small logistical facilities, all of which fall under the category of point

targets. The Soviets practiced the same way. That the Chinese do not write about these issues in detail should not be surprising. The virtue of LACMs is also reflected in their capacity to approach the target at very low angles of attack, whereas ballistic missiles come at the target from high attack angles—an operational advantage that Taiwan's strategists both understand and fear.²¹

The heavy volume of missile fire, referred to as “tidal wave” attacks by one foreign commentator, can also make the challenge of defending against Chinese missile attacks enormously difficult.²² Because of the high cost of ballistic missile defense systems such as the U.S. Patriot, Taiwan has chosen to acquire relatively low numbers of missile defense batteries and interceptors. Adding LACMs to the mix of offensive missiles would severely stress Taiwan's already limited missile defenses, not least because systems like Patriot are much less effective against cruise missiles compared with ballistic missiles. Indeed, even if Taiwan were to improve its cruise missile defenses by adding airborne sensors possessing sufficient precision to detect and track low-flying cruise missiles, “tidal wave” attacks are still a problem. Recall the 9:1 cost advantage of cruise missiles to cruise missile defense that some Chinese sources perceive. Such a belief may help explain a report from the PLA's *Military Digest* in May 2007 indicating that China may transform more than 1,000 retired Jian-5 fighters into cruise missiles, the cost of which, according to a Taiwan analyst, would be roughly \$100,000 for each conversion.²³ Given the large number of obsolescent Chinese aircraft leaving service, this appears to be a promising area for further development. By contrast, U.S. PAC-3 interceptors appear to cost \$3 million per missile. Launcher and missile numbers truly make a difference: quantity may have a quality all its own.

Assessment of China's Potential to Proliferate Cruise Missiles and Related Technology¹

China has joined a small but growing group of states capable of developing advanced LACMs embodying 1990s-era technological sophistication drawn largely, in China's case, from Soviet and Russian assistance.² Although Chinese cruise missiles are not state-of-the-art, they have significant capabilities. Potential sales of complete cruise missiles, production equipment, and critical subsystems (engines and guidance) could enable developing countries—including some hostile to U.S. interests and others embroiled in regional hostilities—to acquire or produce LACMs of significant military concern to U.S. forces and other regional militaries. For example, should China become a significant supplier of advanced ASCMs to Iran, particularly missiles possessing supersonic speeds, or assist Iran in furthering its nascent LACM development programs, the antiaccess challenges for any opposing forces could be greatly increased. At the very least, such developments would severely test U.S. and allied missile defenses, especially if Iran acquired large inventories of LACMs and ASCMs.³ China is already suspected of aiding Pakistan's growing LACM ambitions,⁴ which have exacerbated arms races in South Asia.

Responding to Islamabad's new LACMs, India is greatly expanding its already ambitious cruise missile plans by pursuing new long-range LACMs capable of generously exceeding the 300-km range of its BrahMos cruise missile.⁵ Even worse, India has coupled such precision strike weapons to a new military doctrine called Cold Start, emphasizing lightning conventional strikes on Pakistan before that state could respond adequately.⁶ Such destabilizing tendencies would only be further exercised if China were to expand its cruise missile exports. Yet the prospect of foreign sales of both antiship and land-attack cruise missiles could reverse the trend of declining PRC arms sales. Therefore, China's willingness to accept and adhere to its nonproliferation commitments on cruise missiles and related dual-use technologies has important security implications.

If China's past record of proliferating ballistic missiles and missile technology is a useful prologue to the future of Beijing's cruise missile activities, the consequences could be profoundly disruptive.⁷ While evidence is not crystal clear that China has already engaged in LACM proliferation or in providing related technologies, the probability appears reasonably strong. At the very least, it has transferred ASCMs that could provide a basis for future LACM development—with or without China's direct aid.

As discussed in chapter 3, Iran is reportedly converting Chinese-furnished Silkworm ASCMs into an antiship missile called Ra'ad with a range of around 300 km, and is also upgrading 300 Chinese-furnished HY-2 Silkworms, outfitting them with a more capable, sophisticated turbojet engine and new land navigation systems. Chinese entities or other foreign sources of civil engines could be candidates to provide a turbojet engine, as these entities and sources have been implicated in selling Iran not just the FL-3/HY-1 Silkworm, FL-3A/HY-2 Seersucker, and C-801 Sardine ASCMs but also the HY-4 Sadsack, which comes equipped with a turbojet engine.⁸ Iran has also deployed a number of ASCMs of Chinese origin. The C-802 is deployed by Iran's navy on three frigates and 10 missile craft and by the Revolutionary Guard Corps Navy on 10 missile craft. Iran has also deployed HY-2/CSS-3 Seersucker cruise missiles in coastal defense batteries and C-802s on Qeshm Island in the Strait of Hormuz.⁹

Evidence is thin in the case of Chinese support to Iran's LACM ambitions although China has long supplied many of its ASCMs to Iran.¹⁰ As noted, Iran is believed to be converting Chinese-furnished ASCMs from the HY series into LACMs. The mere transfer of ASCMs would not violate the MTCR, to which China is a pledged—albeit questionable—adherent. However, should the Beijing government or PRC entities be engaged in providing restricted engine technology or fully integrated flight management systems to Tehran, such activity would violate Category II provisions of the MTCR.

When Pakistan surprised India with the launch of its Babur LACM in August 2006, most analysts concluded that China had assisted Islamabad substantially in acquiring its new LACM capability.¹¹ Indeed, Pakistan has not only continued to test Babur, which is purported to have a range of 700 km or more, but has also begun testing a 350 km range LACM called Raad (Iran has also assigned this name to its new ASCM) as of August 2007. Naturally, Indian observers view Babur's origin as Chinese. The most detailed analysis appeared in *New Delhi Force*, an Internet-based version of an independent Indian monthly national security magazine.¹² This article outlined a scheme in which Pakistan reached agreement with the CPMIEC to provide Pakistan with one regiment of LACMs including command posts and logistical support vehicles—in short, a complete LACM capability. CPMIEC was to act as the prime contractor responsible for supplying all component parts for licensed assembly in Pakistan. But the credibility of this argument became suspect when the same author, 6 months later, wrote a second account of Babur's origin with a completely different set of players involved including Pakistan's notorious A.Q. Khan.¹³ The only cruise missile connection that appears relatively clear is that Pakistan gave China access to unexploded Tomahawks that were launched at al Qaeda targets in Afghanistan in 1998 but that landed errantly in Pakistan. Given the unreadiness of Pakistan's purely indigenous capabilities to undertake a sophisticated LACM program entirely on its own,

it appears reasonable to believe that the Chinese government or its military-industrial entities assisted Pakistan in acquiring a LACM capability.¹⁴

The Pros and Cons of China's Membership in the MTCR

China is not a full member of the 34-nation MTCR. It began to seek membership actively in 2004 but has thus far been denied due to concerns about its poor proliferation record. Currently, Beijing is an adherent to the MTCR's guidelines of behavior. The reason China represents a critical wild card with regard to enabling the further spread of cruise missiles is that Beijing's current pledge to stand by the MTCR's general guidelines is problematic, especially regarding cruise missiles and UAVs. Whereas MTCR guidelines are merely a set of broad principles, the technology annex provides specific details on what technologies should be controlled. Upon agreeing to observe the MTCR guidelines in 1994, China formulated a unique version of what adherence meant. Specifically, Beijing agreed "not to export ground-to-ground missiles featuring the primary parameters of the MTCR." This statement suggests that air-to-ground missiles (namely air-launched LACMs) were not included in China's view.¹⁵ When Washington agreed to waive sanctions against Chinese entities for missile-related exports to Pakistan and Iran in 2000, Beijing agreed not to export nuclear-capable ballistic missiles and related technologies and to publish an MTCR-like export control list. This agreement was hailed in Washington as a diplomatic achievement even though the State Department reiterated China's restrictive reference to "nuclear-capable ballistic missiles" alone.¹⁶ As the Bush administration came into office in 2001, officials admitted that Washington needed "to do additional work to clarify China's willingness to implement fully the terms of the November 2000 agreement."¹⁷

The November 2000 agreement at least hinted that China's approach to missile export controls might eventually be brought closer in line with the MTCR. In a policy statement on missile nonproliferation made without specifically referring to the MTCR, the Foreign Ministry promised to issue new export control laws covering missile transfers.¹⁸ China delivered on its promise in August 2002 when it published the "Chinese Missile and Missile Technology Regulations and Export Control List," which included virtually all MTCR Category I (complete systems and subsystems) provisions but fell significantly short of treating Category II systems and dual-use technologies that require case-by-case review before their sale. Upon its release, China's lead arms control official observed, "There are items not contained in MTCR in the list. So in this respect, this list covers a wider area than MTCR. Of course there is also a very limited number of MTCR items that are not in the list because they are not really that relevant, either because we don't have them, or they have never come into the picture, or because our experts do not know exactly what they are."¹⁹

Among the “very limited” Category II items not covered were GPS technology and delivery systems with a range equal to or greater than 300 km regardless of the weight of the payload, a provision added by MTCR member states in 1993 to expand the regime’s mandate to include chemical and biological delivery systems. Cruise missiles, being so much more effective than ballistic systems for chemical and biological weapons delivery, were foremost on the minds of MTCR members when they expanded the MTCR annex in 1993.²⁰ Thus China’s future status regarding the MTCR stands as a critical challenge for the Obama administration.

China’s prospective membership in the MTCR first became an issue after Beijing applied in July 2004.²¹ Following failure to reach a consensus on Beijing’s application in the October 2004 MTCR plenary in Seoul, the issue arose again at the 2005 plenary in Madrid, but the regime’s members were not even willing to consider the matter. According to U.S. and British officials, the membership largely remained concerned about inconsistencies in China’s implementation record vis-à-vis MTCR standards.²² Besides having transferred a nuclear warhead design and nuclear test information to Pakistan, Beijing has continued its missile-related activities with Iran in spite of repeated U.S. sanctions. The apparent Chinese parentage of Pakistan’s Babur LACM does not engender confidence in Beijing’s nonproliferation performance. Beijing’s enforcement record is also reason to be concerned about its admission to the MTCR.

The scale of China’s export control challenge is enormous, not least because of the country’s immense land, sea, and air borders and the cumbersome and inherently conflictual nature of its bureaucratic components. In addition to generating the political will to act decisively, China will have to invest substantial financial resources to acquire the highly trained personnel and new technology needed to bring the nation up to even minimum essential standards. That is unlikely to happen until Beijing appreciates the fact that its long-term economic interests are intricately linked to its nonproliferation performance. Instead of stonewalling against China’s entry into the MTCR, the regime’s membership should work more closely with China in ways that foster increased transparency and improved enforcement.²³ Extending the capacities of the State Department’s Export Control and Related Border Security program to Beijing, especially in the area of export control and nonproliferation training, represents one of several possible courses of action worthy of implementation.²⁴

On balance, it would be better to have China operating from within the MTCR than as a mere adherent. Even though China was a target country for years, it was permitted to join the Nuclear Suppliers Group (NSG) in 2004. Critics raised most of the same concerns about Beijing’s poor proliferation track record and weak enforcement mechanisms to argue against its NSG accession, but Bush administration officials countered that China had made enough improvements to warrant membership.²⁵ Formal accession to the

MTCR would mark not only China's involvement in a key security institution it doubted for many years, but also more broadly its increasingly close engagement in international economic and political institutions. Continuing to block accession could backfire by encouraging Beijing to return to its past proliferation behavior regarding missile sales. That would make it easier, not harder, to subvert U.S. security interests from the comfort of its imprecise and occasionally self-serving adherent relationship with the MTCR today.

Conclusion

China's cruise missile programs began in the late 1950s largely in response to the need for coastal defense and were assisted by the Soviet Union, which provided the models, blueprints, and technologies relevant to ASCM development. Despite the Sino-Soviet split, China overcame significant difficulties and was able to manufacture, trial test, and eventually test launch its first generation of ASCMs in the early 1960s and introduce these weapons into the PLA in the late 1960s. The SY-series ASCMs have evolved over the years into over 20 types of systems including the (in)famous HY/Silkworm and C-801/802 exported to Iran. Beginning in the 1990s, China started LACM development/acquisition, prompted in part by the extensive U.S. use of Tomahawk missiles during the Gulf War of 1991. With both indigenous efforts and assistance from Russia, including technologies and scientists, China has tested and deployed at least two models of LACMs, the DH-10 and YJ-63.

Over the past five decades, China has made the greatest progress in its ASCM inventory, making its navy one of the most ASCM-equipped compared to other major naval powers. Most of the PLAN's surface ships and many of its conventionally powered submarines now have as a significant portion of their weapons loadouts ASCMs that pose credible threats to surface warships including carrier groups. Nearly every surface combatant's main weapon battery employs ASCMs.¹ As William Murray notes, "This in many ways is a completely new and even transformative way for the PLA to conduct ASUW, but it has a precedent. The Soviets built *Sovremenny*- and *Slava*-class cruisers and deployed both Blackjack and Backfire bombers as a means of delivering advanced ASCMs against their most likely opponents. They also built the *Echo II*-, *Charlie I & II*- and *Oscar*-class SSGNs to compound the ASCM threat NATO surface ships faced."²

The Chinese are continuing to improve and introduce a variety of modified ASCMs and increasingly are showcasing them at international air shows to attract customers. China's ASCM designers and engineers are developing new ASCMs that are capable of being deployed on a range of platforms and launched from undersea, at sea, from shore, and from the air.

Available estimates, as well as the PLA's focus on unresolved territorial and maritime claims, suggest that China's cruise missile launch platforms will continue to improve in quality, sophistication, and coordination but will not increase significantly in overall numbers. For example, unclassified projections from the Congressional Research Service

suggest that, while the PLAN had 137 large surface ships in 2012, this number will only increase to 146–147 by 2015 and will likely remain at that level through 2020. Estimates for PLAN aircraft project a more significant increase: 179–245+ (2012), about 468 [+ helicopters] (2015), and about 505 [+ helicopters] (2020). A large proportion of the projected increase comes from assuming that China will transition from zero carrier-based fighters in 2012 to approximately 90 in 2020.³ The total number of PLA aircraft, the majority of which are presently in the PLAAF, might well rise at a slower rate.

Initially developed largely for coastal defense purposes, ASCMs today form an important component of China's strategies of deterrence and access denial around and beyond the Taiwan Strait. The deployment of LACMs further enhances the PLA's abilities to attack from long distances and therefore hold off U.S. intervention during crises in the strait. The growing importance of cruise missiles in military and campaign doctrines is a reflection of Beijing's recognition of the following developments. First, U.S. application of Tomahawk LACMs during the two Gulf Wars and the Kosovo and Afghan operations demonstrated to the Chinese military high command that cruise missiles are effective, difficult to defend against, and relatively low-cost weapons that can deliver precision strikes from a distance with low casualties. PLA analysts also noted the successes of ASCM use by weaker parties during the 1967 Six Days' War and the 1982 British-Argentine conflict over the Falkland Islands. In other words, it was seen that cruise missiles help provide the initiative and lethality that, in turn, can be critical in determining winners and losers in modern wars, which tend to be localized in geography, high-tech in weaponry, and short in duration.

During the latter stages of the Cold War, the PLA reportedly viewed cruise missiles as part of a military development plan to deter military, particularly nuclear, attack from Russia. It believed cruise missiles were vital to the affirmation of China's technological and economic development status. Chinese military experts argued further that LACMs could facilitate a rapid increase in combat capabilities by supplementing an outmoded and difficult-to-reform air force. Cruise missiles were perceived to be a cheap, accurate, and effective way to improve air combat ability. The technology was believed to be mature, their guidance and control were relatively simple, and environmental factors did not significantly interfere with their operation.⁴

Second, with widespread U.S. deployment of missile defenses, the introduction of the PAC-3 systems into Taiwan, and the likelihood of intervention by U.S. carrier strike groups in a crisis in the Taiwan Strait, cruise missiles could penetrate missile defenses in attacks on land targets and serve as "carrier killers" that could neutralize the U.S. capability to defend Taiwan. Chinese LACMs have the potential to neutralize land-based Patriot batteries, and ASCMs have the potential to neutralize CSGs. This may explain why, over the past decade, the PLAN has fielded such a large number of ASCMs that an

overwhelming asymmetry has been established in the Western Pacific where U.S. ASCMs are now outnumbered seven to one.⁵ In that context, U.S. maritime superiority may be undermined by the large number of increasingly capable ASCMs the PLAN deploys on its surface warships and submarines. This so-called “assassin’s mace” augurs the prospect of the Chinese military deterring a much stronger opponent and thus supports a strategy of “not losing” in an asymmetrical operation environment. At the same time, LACMs operating in tandem with conventionally armed ballistic missiles could provide the PLA with sufficient firepower to increase the effectiveness of its still limited air force to quickly gain a decisive advantage over Taiwan’s forces before U.S. intervention is possible.

Third, given the many potential advantages of ASCMs, the degree to which the United States has neglected to deploy them is striking. As mentioned previously, U.S. Navy surface forces’ ASCM inventory consists solely of Harpoons and not in great quantity. While the U.S. Navy and its Chinese counterpart have different forces and operational priorities, it would seem ill advised for the United States to limit itself so severely in both the type and the quantity of ASCMs.

Fourth, Beijing is acutely aware that its cruise missile inventory, while growing and becoming more advanced and versatile, may become vulnerable to missile defenses and that its cruise missile launch platforms are subject to attack.⁶ But it is making progress in this and other areas. For example, China has already deployed Beidou I fully and is in the process of deploying Beidou II/Compass, which will provide its own source of accurate satellite navigation. Further, the DH-10 is believed to use TERCOM midcourse navigation, which obviates any need to depend on GPS or GPS-like satellite navigation signals. Moreover, the United States has canceled major cruise missile defense programs that would be valuable against such threats over land. Nevertheless, any lingering dependence on the U.S. GPS or Russian GLONASS systems could seriously limit or even paralyze operational effectiveness of Chinese cruise missiles should access to these systems be either denied or become unavailable due to technical difficulties. Similarly, China also recognizes the need to defend itself against enemy cruise missile attacks.

The limited open-source information we have used for our analysis suggests that China has made significant progress in cruise missile developments over the past five decades. Still, a number of issues could remain as obstacles to the modernization of its ASCM/LACM inventory. As with its ballistic missile development, development of various ASCM and LACM prototypes/systems, from design to factory trial tests to launch tests, typically has taken a considerable time, sometimes more than 20 years. Granted, in the 1960s and 1970s, China experienced significant disruption in its weapons development programs due to the upheaval of the Cultural Revolution, but the rather modest rate⁷ with which many of China’s new generation weapons systems have come through to fruition (at least until recently) indicates a defense industry that still faces challenges

Sources and Limitations of Open-source Analysis

This study draws on a variety of Chinese and English language sources. In descending level of demonstrated authority, Chinese sources include PLA doctrinal publications describing how cruise missiles might be used in operational scenarios, specialized technical analyses from identified civilian and military institutes of many specific aspects of such weapons and their supporting infrastructure, didactic PLA discussions, generalist deliberations on the development trajectory and operational use of cruise missiles, and unattributed speculation on a variety of Web sites.

Official military doctrinal publications provide guidance for PLA personnel. They are typically written by leading military scholars at professional military education institutions. These scholars often write under the editorial guidance of high-ranking active-duty officers, or sometimes are retired senior officers themselves. An example cited in this study is *The Science of Campaigns* [战役学]. Technical analyses, though typically focused on Western systems rather than Chinese systems, and limited in their discussion of actual Chinese weapons capabilities, are written by military and civilian technical analysts whose names and institutions are typically identified for an audience in their relevant subfields. *Winged Missiles Journal* is the most widely considered source here. Other deliberations on cruise missiles fall into three categories: PLA publications (typically published by a service's political department, for example, *Modern Navy* and *People's Navy*), defense trade publications (for example, *Naval & Merchant Ships* and *Modern Ships*, affiliated with China's state shipbuilding industry), and enthusiast sites on the Internet. All must be analyzed with caution. The first two are clearly more demonstrably authoritative, but all three share a range of larger patterns: they are written by a variety of naval and maritime analysts (many unidentified) for a broad range of military, defense industrial, and popular audiences, some perhaps for educational purposes. The veracity of these sources is frequently difficult to determine although many of the commentators appear well informed.

Some Chinese commentators writing in unofficial venues may be privy to internal deliberations or even play roles in shaping policy, particularly in specialized subject areas. Now that China has what could be termed a public and military-intellectual complex, analysts and policy entrepreneurs may be jockeying for position in an attempt to influence decisionmaking. When politics or bureaucratic maneuvering comes to the fore, individual analysts may become caught up in larger competitions of ideas. But even the views of those not directly involved in the policy process often matter; their ideas may inform policymakers or may even be adopted. Some analyses may well be informed by parallel debates in official circles and even be designed to help justify or "socialize" already established policies—for instance, through didactic exploration of important concepts.¹

These Chinese sources were supplemented with a wide variety of English language sources, including (again in descending level of demonstrated authority) U.S. Government reports (the Department of Defense and Office of Naval Intelligence), analyses by scholars and think tanks (RAND), and online information databases (the unofficial but apparently generally accurate *Jane's* and *Sinodefence.com*). In doing so, the authors faced a common dilemma in assessing China's still largely opaque military: the most authoritative documents tend to cover general issues only; for specifics, it is often necessary to consult sources whose provenance is less clear. Fortunately, the diversity of data points and the authors' combined decades of experience in the fields of technical analysis, arms control, and Chinese analysis allowed information to be compared and assessed for reliability. The result is a product whose details must be treated with caution, but whose larger points are likely to hold.

That said, several broad caveats are in order. Considerable gaps remain between what is known of China's cruise missiles programs in terms of the actual systems, people, organizations, and integration into the PLA order of battle. Nor are we able to evaluate the effectiveness of systems aside from their advertised and reported test results, unlike publicly available information on the performance of U.S. Tomahawk land-attack cruise missiles given the latter's extensive use extending well over a decade. While we have done our best using open-source information to sketch as accurately as possible the various Chinese ASCMs/LACMs along with their origins, evolution, and characteristics, more research is required to ascertain the accuracies of reporting in the existing literature that our study is based on. Likewise, given that China's defense industry has undergone significant reforms over the past decade and that many Chinese defense conglomerates are responsible for the design, production, and sales of a wide range of weapons systems other than ASCMs/LACMs, there is a need for further investigation into which specific research institutes and factories are involved in cruise missile development. More research is also needed on how decisions on cruise missile development and production are made, including the exact chain of command; how decisions are made on designs, designation, and induction; the division of labor between the military (represented by the General Armament Department) and the civilian SASTIND; and what coordinating bodies adjudicate and resolve disputes.

Note

¹ This paragraph draws on Andrew S. Erickson and David D. Yang, "Using the Land to Control the Sea? Chinese Analysts Consider the Anti-Ship Ballistic Missile," *Naval War College Review* 62, no. 4 (Autumn 2009), 53–86.

in meeting the needs of the PLA.⁸ While reform over the past decade has significantly improved the industry as a whole, systemic problems persist and may impose constraints on its ability to produce advanced cruise missiles at a greater pace.

China continues to depend on foreign assistance to overcome critical bottlenecks in design, engineering, and materials, though this reliance is decreasing. The United States and European Union post-Tiananmen ban on arms sales to and defense cooperation with China limits Beijing's choices of sources of supplies and assistance to some extent, but Europe's financial woes offer the prospect of the embargo unraveling, particularly as it is based on consensus.⁹ Russia and a number of other countries have been able to fill the void, selling Beijing a variety of highly advanced weapons systems and even serving as sources of key technologies and engineers. At the same time, Moscow, despite the commercial need to sell arms to sustain its own defense industry, has been at times reluctant to provide Beijing with all the weapons systems and military technologies it seeks. Due to its membership in the MTCR, Russia is not permitted to provide China complete cruise missile systems or subsystems that support the capability to deliver a 500 kg payload over a range of at least 300 km. Nor has it been willing to transfer at least some relevant and critical technologies, notwithstanding media reports of secret Sino-Russian pacts and Russian scientists and engineers working in Chinese defense industrial sectors.¹⁰

Remaining Uncertainties

China's considerable time and investment in cruise missile development is paying off in the form of a significant increase in capabilities that is set to continue, although not without challenges. Timothy Hu, writing in 2007 in *Jane's Defence Weekly*, argued that the PLA's missile forces would allow China to gain military ascendancy over Taiwan by 2010.¹¹ In retrospect, this estimate seems slightly optimistic on mainland China's part but nevertheless is indicative of a powerful trend. The addition of LACMs to China's already large (1,000–1,200) inventory of SRBMs presents a formidable challenge to Taiwan, but two caveats must be considered. Force modernization depends on more than relentlessly building up missile inventories. The ability to employ these weapons to maximum advantage depends on a multitude of additional factors, three of which bear mentioning.

First, a key question is whether China possesses the C4ISR capabilities to make the best use of its ASCMs. As William Murray explains, "Nearly every tactical method of accurately firing long-range ASCMs, by any vessel or aircraft, relies on remote targeting . . . it is reasonable to assume China has assessed what is necessary, and is investing aggressively to satisfy those requirements. The PLA's OTH radar and ever-improving constellation of reconnaissance satellites are strong indicators of this."¹² Murray notes that China would also need to be able to pass targeting data to the platforms tasked with firing the ASCMs.

In the case of attack submarines, this might involve the use of satellite, high frequency (HF), or very low frequency (VLF) radio transmissions.¹³

Second is the challenge of carefully orchestrating a complex, multifaceted air and missile campaign over many days. A successful campaign depends on both human and technical factors—extremely well-trained military personnel who have practiced these routines in diverse ways over many years and the command and control architecture needed to deal with complex combined-arms operations. Chinese planners envision establishing a Firepower Coordination Center (FCC) within the Joint Theater Command, which would manage the application of air and missile firepower. Separate coordination cells would be created to deal with missile strikes, air strikes, special operations, and ground and naval forces.¹⁴ Absolutely critical to achieving the delicate timing between waves of missile strikes designed to leverage the effectiveness of subsequent aircraft attacks is developing the skill to coordinate and deconflict large salvos of missiles and waves of aircraft operating in multiple sectors.¹⁵ It is unknown whether China is confident that it can execute such a complex joint campaign.

The third factor is a less obvious but nonetheless essential element to successful use of cruise missiles:¹⁶ the optimization of missiles to achieve their desired mission objectives. Conventional wisdom has it that the revolution in information technology easily enables the precision delivery of conventional payloads over great distances in the form of LACMs aided by advances in GPS technologies. To be sure, the advent of GPS technology has eased the process somewhat for states wishing to employ LACMs. But the process of becoming truly proficient requires more than access to technology. In this regard, bomb damage assessment (BDA) is vital.¹⁷ What is unique about today's Tomahawk LACM, even its latest Block IV version, is the extent to which its performance has benefited from years of feedback from system diagnostics collected ever since the first Tomahawk was introduced in the 1970s. Virtually each and every Tomahawk, in peace and war, has been analyzed to determine precisely what accounted for the missile's performance, no matter whether the missile crashed after taking off or hit precisely where it was programmed to hit.¹⁸ To learn from such successes and errors requires that missile developers have the kind of sophisticated diagnostic equipment that provides hints about system performance, but also highly skilled systems integration specialists with specialized knowledge accumulated over years of interaction with other skilled missile developers. The use of Tomahawks in multiple contingencies since the first Gulf War in 1991 has facilitated the creation of an enormously valuable store of knowledge that lends itself to steady improvement in LACM performance.¹⁹ While China surely will not need over three decades to develop high confidence in LACM performance, it will require time and dedicated effort before it can expect to have high confidence that its LACMs will perform as desired, particularly in combined arms campaigns. Presumably, China's lack of combat experience limits its

ability to incorporate feedback into its own learning process.²⁰ It remains uncertain to what extent China can achieve its command and control objectives until it has gained more experience under realistic training circumstances.

The future development of China's cruise missile systems will depend on a number of factors. One is the role of ASCM/LACM in Chinese defense doctrines and military campaign strategies and their cost-effectiveness compared to other weapons systems.²¹ These considerations will influence and, in turn, be affected by competing budgetary requests for different weapons systems and procurement priorities. Second, cruise missile development, and indeed China's overall defense modernization, will be determined by the government's priorities as Beijing assesses the economic, social, and defense needs against the security environment and perceived and real threats. Third, U.S. military developments including missile defenses, its own deployment and use of offensive weapons, and its intentions over the Taiwan Strait will also influence how China will react and hence what role cruise missiles will likely play. Finally, China's defense industry will continue to be a critical factor in the extent and scope of where its cruise missiles can further develop and close the technical gap with other major powers such as the United States and Russia, barring (and even with) the lifting of arms embargoes (for example, in EU nations) and a Russia more willing to provide the necessary technologies and the skill that ordinarily derives from extended face-to-face work on joint programs.

The biggest challenges facing China remain in the area of advanced propulsion systems including not only turbofan engine technology but also hypersonic propulsion. If China is to achieve its expressed goals with hypersonic cruise missiles, it will need to make a substantial investment in accumulating a knowledge base in emerging propulsion systems. Only the stiffest of many of the challenges faced in this regard include dealing with engine system dynamics, advanced lightweight, high temperature materials development, and appropriate cooling technologies to cope with an extremely stressing aerothermal environment.²² To be sure, Chinese engineers do a thorough survey of technological bottlenecks to identify and target possible sources. However, to pursue advances in an area where China cannot rely on acquiring dual-use components, engineers will have to acquire the advanced knowledge that comes from learning on their own over time or working closely with a willing advanced technology partner to achieve the goals they write about.

China has come a long way in a short time. Its successful efforts to develop ASCMs and LACMs have produced a significant increase in PLA capabilities. ASCMs and LACMs, along with other systems, are key components in efforts to develop A2/AD capabilities that will increase the costs and risks for U.S. forces operating near China including in a Taiwan contingency. LACMs give China new options for conventional strike. These apply most to Taiwan, where ground-, air-, and sea-based systems could be

employed; but they are also concerns to Japan and the U.S. territory of Guam and provide a limited capability wherever the PLAN can deploy. Effective ASCMs give the PLAN an expeditionary capability and an ability to take on other navies. China plans to employ cruise missiles in ways that exploit synergies with other strike systems and can allow cruise missiles to degrade air defenses and command and control to enable air strikes. Defenses and other responses to PRC cruise missile capabilities exist but will require greater attention and a focused effort to develop countermeasures and other responses.

Appendix A

History of Chinese Cruise Missile Institutes/ Defense Management System

China's cruise missile programs have Russian origins, although China was gradually able to move beyond licensed production and reverse-engineering to creation of indigenous variants. Exports began in the early 1980s. China regained access to Russian platforms and missile technology in the early 1990s. Today some cruise missiles in the PRC inventory are imported directly from Russia while Chinese factories are producing increasingly capable systems that often incorporate or benefit from access to foreign components and technical assistance.

Despite having to face the daunting challenges of rebuilding China in the aftermath of a devastating civil war (1946–1949) and the Korean War (1950–1953), Chairman Mao Zedong determined that for national security reasons it was absolutely imperative to establish and develop a domestic defense industrial base. Both resources and organizational structure were provided and put into place to guide and organize such efforts.¹ Over the years, the government ministries and agencies as well as key research institutions that have played a critical role in and continue to manage China's cruise missiles R&D, prototype production and testing, and adoption and serial production have undergone many organizational changes. But the programs themselves have remained surprisingly intact even during years of political upheaval such as the Cultural Revolution.

China began introducing SAMs and ASCMs in the late 1950s. Following the February 1950 Treaty of Friendship, Alliance, and Mutual Assistance and the first Five-Year Plan for industrial and agricultural development and production (1953–1958), and soon after the signing of the 1958 bilateral accord on defense cooperation, the Soviet Union transferred the 542/KS-1 shore-to-ship and 544/P-15/Styx SS-N-2 antiship missiles and SA-2 SAMs.² Despite the departure of Soviet advisors in September 1960 in the wake of the Beijing-Moscow fallout, the Chinese persevered against all odds and conducted their first successful missile test in November 1960.³ During that year, China started copy production of the SA-2 under the name Hongqi-1 (Red Flag). The missile's initial classification process was completed in December 1964, and in June 1966 copy production work ended.⁴ An air-to-ship missile research department was established in 1966. Hongqi-2 was "classified" in July 1967 and was first used to shoot down a U-2 reconnaissance aircraft on September 8, 1967.⁵ China began R&D on an improved version of the missile, now named "Hongqi-61," according to Chinese historical sources. Design work began in 1970,

and 12 research institutes, 11 factories, and 2 test bases, together with other military and civilian units, participated in this major project. Test launches were conducted in the early 1980s, and after several failed attempts Hongqi-61 finally achieved successful test results. In November 1988, the Defense Products Prototype Designation Committee of the Central Military Commission (CMC) and the State Council approved the finalization of the missile system, which is now deployed on *Jiangwei*-class frigates.⁶

The Soviet Union provided China with the first batch of cruise missile models and technical data in 1959 in accordance with the October 1957 Sino-Soviet New Defense Technical Accord and the February 1958 bilateral agreement, which specified that the Soviet side would provide assistance to China's missile programs including the supply of the Type 542/KS-1 and Type 544/P-15/Styx SS-N-2A ASCMs.⁷ The Fifth Academy under the Ministry of Defense was assigned the lead role in coordinating national efforts in ASCM research, design, and licensed production. Established on October 8, 1956, with Qian Xuesen (Tsien Hsue-shen) as its first director, the Fifth Academy was instrumental in China's ballistic and cruise missile developments.⁸ Qian received his education from MIT and Caltech and had worked on rockets and advised the U.S. military during World War II. In the early 1950s, he became a suspected target during the McCarthy era and was deported to China in 1955. Soon after that, Qian used expertise honed advising the U.S. military and inspecting captured Nazi scientists and V-2 rockets to take a vital part in establishing China's aerospace program. Working with roughly 100 foreign-educated scientists who also returned to China during that period, he initiated and directed the country's missile programs, playing a critical role from the late 1950s through the 1970s.⁹

Office No. 40 and an assembly line for ASCMs were set up in the Nanchang Aircraft Manufacturing Company in 1960 to initiate copy production. Even before the cruise missiles were manufactured, the CMC instructed the PLAN headquarters to select an ASCM test site. To support these efforts, several test sites for ASCMs were selected and constructed with the first one located in Liaoxi, Liaoning Province. Work started in 1958 and was completed in late 1963.¹⁰ Many of China's ASCM tests, such as those for Shang You-1 and the Hai Ying-series, were undertaken there.¹¹ Production began in October 1963, and China's first ASCM, a license-produced version of the Soviet P-15/SS-N-2A "Styx," passed factory tests in August 1964. A year later, the first missile test was successful. Subsequent tests led to further improvements, and in August 1967, the missile, designated Shang You-1 (SY-1), was approved for production and entered service in the late 1960s. An indigenously improved version, Hai Ying-1 (HY-1 or "Sea Eagle"), was successfully tested in December 1968 and entered service in 1974. In October 1969, Premier Zhou Enlai reportedly approved the establishment of a Military Industry Enterprise Base to produce antiship cruise missiles. Other derivatives from the Soviet P-15 include the Fei

Long 1 (Flying Dragon), HY-2, HY-4, YJ-61, and the YJ-series were designed by the Third Academy and manufactured at the Xi'an Aircraft Factory.

Over the years, the Fifth Academy and other Chinese defense R&D institutes and manufacturing facilities have been under the supervision of the central government's ministry or commission responsible for national defense industries. Despite the changes over the years, a number of points deserve particular attention. One is that regardless of the political upheavals and/or economic difficulties, the Chinese government has placed high priority on and devoted significant resources to building the defense industrial base, often with prominent leaders taking the reins. Marshal Nie Rongzhen, for instance, was for many years at the helm and instrumental in guiding defense industrial developments.

Second, within the defense industrial infrastructure there have always been efforts to recruit the best and brightest, and many of these scientists and technicians have returned from overseas. Again, under Marshal Nie, and supported by Premier Zhou Enlai, faculties and departments on nuclear engineering and missile research were established in a number of military and civilian institutions, which in turn played a critical role in training new generations of defense scientists and technicians. During the Cultural Revolution, when political movements and the radical activities of the Red Guards inflicted serious harm on the intelligentsia, Nie made great efforts to protect those who worked on nuclear weapons and missiles.

Third, concentration and efficient employment of resources, coordination of efforts from multiple organizations, and prioritization of key projects for breakthrough have enabled China to achieve significant progress in nuclear weapons, missiles, and space.¹²

Fourth, coordination of defense R&D, procurement, production, and test trials have been attempted, and decisions on systems adoption have been facilitated through centralized organizations and their periodic reorganization. In January 1951, the Central Military Commission Ordinance Committee was established, with Premier Zhou Enlai as the director and Nie as one of two deputy directors. In April of that year, Nie was also appointed director of the Aerospace and Industrial Management Committee in charge of missile and aerospace developments. The committee was subsequently renamed the National Defense Science Commission, the central government's supervisory arm overseeing all defense related R&D and production activities, from organizing projects to protecting and testing new weapons systems. It should be pointed out that it was Marshal Nie who in May 1956 proposed the establishment of the Missile Administration Bureau, or the Fifth Bureau, and the Academy of Missile Research, or the Fifth Academy, under the Ministry of Defense, and who specifically recommended that Qian Xuesen be appointed director of the latter organization.¹³ In January 1965, Division Three of the Fifth Academy was separated out to form the new Third Academy, which concentrated on cruise missile research, design and development, and small-scale production. That

April, the State Council decided to assign a number of factories, research institutes, and personnel mainly from the Seventh Ministry (but also from other ministries) to the Third Academy to accelerate cruise missile research and development.

Appendix B

Overview of China Aerospace Science and Industry Corporation Third Academy

The China Aerospace Science and Industry Corporation (CASIC) is one of China's most prominent aerospace and defense enterprises.¹ Formed in June 1999 and employing more than 100,000 people, its products include short- and medium-range solid fueled ballistic missiles, antiship and land-attack cruise missiles, air defense systems, antisatellite (ASAT) kinetic kill vehicles, tactical satellite launch vehicles, tactical microsatellites, command and control systems, and a broad range of associated subsystems and components. CASIC also supports national-level requirements for basic research in aerospace science and technology.

As a first-tier contractor, CASIC is organized in a manner similar to U.S. defense corporations, with a corporate-level structure and various business divisions referred to as *academies*. Like U.S. defense enterprises, each academy focuses on a specific core competency. However, while U.S. defense companies tend to be divided into further specializations within a business division, CASIC academies are organized into R&D or design departments; research institutes focusing on specific subsystems, subassemblies, components, or materials; and then manufacturing, assembly, and testing facilities. Each academy has its own business intelligence institute. CASIC has an export management subsidiary (China Precision Machinery Import and Export Corporation, or CPMIEC), although international sales appear to generate a much smaller portion of its total revenue compared to its U.S. counterparts.

CASIC's Third Academy was formed in Beijing in 1961 and is responsible for most of China's cruise missile design, development, and production. Its cruise missile R&D and manufacturing complex is primarily concentrated in Yungang, a suburb southwest of Beijing. Its most prominent product is the DH-10 [东海-10] land-attack cruise missile. It also produces the YJ-62 ground and ship-launched antiship cruise missile, YJ-82 submarine-launched ASCM, YJ-83 ship-launched ASCM, YJ-63 air-launched LACM, and YJ-91 high-speed antiradiation missile. A 4,000 km variant of the DH-10 is said to be in development.

Organized into headquarters management, systems engineering, subsystem R&D, and manufacturing functions, the Third Academy is staffed by more than 13,000 employees (6,000 of whom are technicians with 2,000 midlevel and senior engineers). The director is Liu Erqi [刘尔琦]. Formerly deputy director of the Second Academy, Liu

replaced Song Qin [宋欣], who appears to have moved laterally to head up the Second Academy. Liu served as program manager [总指挥] for two systems and is the deputy chief of an unidentified GAD Technical Working Group [总装备部某技术专业组副组长].² Former 33rd Research Institute Director Cui Yuping [崔玉平] serves as the Third Academy director's executive assistant. The Third Academy director is supported by at least four deputy directors. They include Huang Xingdong [黄兴东], formerly director of the Third Academy's 3rd Department, and Liu Depei [刘德培], Shi Xinxing [史新兴], Wei Yiyin [魏毅寅], and Xue Liang [薛亮]. Huang Xingdong [黄兴东] is the Third Academy executive deputy director. Son of a founding father of China's cruise missile program and formerly in charge of the Third Academy's systems engineering department, Huang likely plays a key role in program management. The Third Academy S&T Committee, consisting primarily of retired senior cruise missile designers, functions as an advisory board.³ The Academy headquarters is located on Xili Road in Beijing's Yungang North District.

Systems Engineering

The Third Academy 3rd Department has overall responsibility for managing cruise missile R&D programs. Directed by Gao Wenkun [高文坤], the department is also known as the Beijing Institute of Electro-Mechanical Engineering [北京机电工程研究所].⁴ When a PLA Second Artillery, Navy, or Air Force customer awards an R&D contract for a cruise missile program, senior Third Academy management appears to assign a chief designer from the 3rd Department who leads a team of four to six cruise missile subsystem designers from within the Third Academy or the broader defense industry.⁵ A program manager, often one of the Third Academy deputy directors, is responsible for administrative tasks associated with an R&D contract. Future design efforts appear to be focused on six areas: 1) increased range, 2) greater precision, 3) higher reliability, 4) increased weapon system effects, 5) easier maintenance, and 6) improved electronic counter-countermeasures (ECCM).⁶ The Third Academy classifies cruise missiles as short-range (50 km or less), medium-range (50–120 km), medium-long-range (120–500 km), long-range (500–5,000 km), very long-range (5,000–8,000 km), and intercontinental (above 8,000 km).⁷

Cruise Missile Engine Design

The leading organization for cruise missile engine R&D is the Third Academy 31st Research Institute. Also known as the Beijing Power Machinery Institute [北京动力机械研究], the 31st Institute is located in Yungang.⁸ Among other endeavors, the 31st Institute

has played a role in supersonic combustion ramjet (scramjet) engine R&D, which is a priority in future planning.⁹

Control and Navigation Systems

The 33rd Research Institute, also known as the Beijing Institute of Automated Control Equipment [北京自动化控制设备研究所], designs, develops, and tests cruise missile-related navigation, guidance, and control subsystems.¹⁰ Established in 1965, the institute is located in the Yungang cruise missile complex. In addition to a key assembly facility, a number of other Third Academy research institutes support the 33rd Research Institute. The 8357 Research Institute, also known as the Jinhang Institute of Computers and Communications [津航计算机通讯研究所], is responsible for automated control systems, on-board computers, and automated target recognition (ATR) systems. The 8357 Institute has 420 employees and is located in Tianjin. Also located in Tianjin, the 8358 Institute [天津津航技术物理研究所] conducts opto-electronics-related R&D, including infrared and laser-related guidance.

The 303rd Research Institute [北京振兴计量测试研究所] is responsible for component testing and standardization. Established in 1987, the 304th Research Institute, also known as Jinghang [北京京航计算通讯研究所], is responsible for on-board mission computers and software development. The 239 Factory, also known as the Beijing Hangxing Manufacturing Corporation [北京航星机器制造公司], is responsible for testing and manufacturing electro-mechanical and electronic products, including wireless technology and attitude control systems.¹¹

Seekers

Established in April 1986, the 35th Research Institute specializes in radar and electro-optical seekers and image processing equipment. It is located adjacent to the Third Academy 239 Factory in eastern Beijing.¹²

Materials

The 306th Research Institute was established in June 2002, primarily to support the 3rd Department and manufacturing entities such as the 159 Factory. With more than 150 employees, the institute specializes in structural composite materials and was recently awarded a contract as consultant or supplier for the Commercial Aircraft Corporation of China's (COMAC's) C919 large commercial aircraft program.¹³

Launchers

Cruise missile launchers are designed, developed, and produced by the 8359 Research Institute, also known as the Beijing Institute of Special Machinery [北京特种机械研究所]. Established in 1981, the institute is an integrated R&D and production center located in Beijing's Haidian District and employs 700 personnel.¹⁴

Final Assembly

The Third Academy 159 Factory, also known as the Beijing Xinghang Electromechanical Equipment Factory [北京星航机电设备厂], is responsible for final cruise missile assembly. Covering 350,000 square meters and employing more than 1,500 people, the 159 Factory is located in the primary cruise missile complex in Yungang.¹⁵ Table B.1 shows important departments, institutes, and factories.

Table B.1. China Aerospace Science and Industry Corporation (CASIC, formerly China Aerospace Machine and Electronic Corporation) Suborgans

<p>3rd Department 北京机电工程研究所 三院三部</p>	<p>Established in 1960, the 3rd Department is China's leading cruise missile design and industrial planning organization. Also responsible for conceptual design and preliminary research for most of China's cruise missile systems, it has at least 14 offices dedicated toward various specialties. As of July 2010, the 3rd Department director is Gao Wenkun [高文坤].¹</p>
<p>31st Research Institute <i>Beijing Power Machinery Institute</i> 北京动力机械研究所</p>	<p>Established in 1957, the 31st Research Institute is responsible for design and development of cruise missile engines. The design department is located on Yungang West Road in Beijing's Fengtai District. Overseeing the Institute's overall engine design work is Director Zhao Wensheng [赵文胜]. As the Institute's senior engineer, Zheng Riheng [郑日恒], a graduate of the UK's Leeds and Cambridge Universities, is a leading figure in designing China's future cruise missile engines.²</p>
<p>33rd Research Institute <i>Beijing Institute of Automated Control Equipment</i> 北京自动化控制设备研究所</p>	<p>Established in 1965, the Institute designs, develops, and tests cruise missile-related navigation, guidance, and control systems. The Institute is located on Xili Road, Yungang North District, Beijing. Since at least 2009, the Institute has been directed by Zheng Xin [郑辛]. Deputy directors include Gu Li [谷栗] and Yang Xingwen [杨兴文].³</p>
<p>35th Research Institute 北京华航无线电测量研究所</p>	<p>Established in April 1986 and located adjacent to the Third Academy 239 Factory in Beijing's Dongcheng District, the 35th Research Institute specializes in radar and electro-optical seekers and image processing equipment.</p>
<p>303rd Research Institute 北京振兴计量测试研究所</p>	<p>Responsible for testing and standardization of components and sub-assemblies used in Third Academy cruise missile products.</p>
<p>304th Research Institute 北京京航计算通讯研究所</p>	<p>Established in 1987, the 304th Research Institute is the Third Academy's primary information systems management organization, including software development. The Institute is located in the Beijing district of Yungang.</p>
<p>306th Research Institute 北京特种材料及应用研究所</p>	<p>The 306th Research Institute was established in June 2002, primarily to support the 3rd Department and the 159 Factory (cruise missile final assembly) in composite material design. With more than 150 employees, the Institute specializes in structural composite materials, and was recently awarded contract as consultant and/or supplier for COMAC's large commercial aircraft program. Located in Yungang in Beijing's Fengtai District, the Institute is directed by Ma Rongping [马荣萍].</p>
<p>310th Research Institute 北京海鹰科技情报研究所</p>	<p>Provides research, analysis, and publication services to Third Academy entities.</p>
<p>8357th Research Institute 津航计算机通讯研究所</p>	<p>With 420 employees and located in Tianjin, the 8357th Research Institute was established in 1966. It develops automated control systems, on-board computers, and automated target recognition (ATR) systems. The Institute is located in Tianjin's North District.</p>
<p>8358 Research Institute 天津津航技术物理研究所</p>	<p>Located in Tianjin's Nankai District, the 8358 Institute conducts opto-electronics-related R&D, including infrared and laser-related guidance, as well as ATR processing technology. Its director is Wu Zhixin [吴志新].</p>

8359 Research Institute <i>Beijing Institute of Special Machinery</i> 北京特种机械研究所	Located in western Beijing's Haidian District, the Institute develops missile launchers and is directed by Chen Denggao [陈登高].
159 Factory <i>Beijing Xinghang Electro-mechanical Equipment Factory</i> 北京星航机电设备厂	Established in April 1960, the 159 Factory is China's final assembly facility for the DH-10 and other land-attack and antiship cruise missiles. The factory is said to be 32.5 sqm in area, and has at least seven "sub-factories" [分厂] and three manufacturing-related R&D centers. Situated in Beijing's Fengtai District, the 159 Factory is managed by Ni Shumin [倪树敏].
239 Factory <i>Beijing Hangxing Manufacturing Corporation</i> 北京航星机器制造公司	Hangxing is a facility for manufacturing, assembly, and testing of electro-mechanical and electronic products, including wireless technology and attitude control systems. Located in Beijing's Dongcheng District, the plant is managed by Li Wenzao [李文藻].
Hong'en Propulsion Technology Co. 北京航天宏恩动力技术有限公司	Established in August 2002 and located in Beijing's Fangshan District, Hong'en manufactures small turbojet engines, including the HN-40-20, HN-40-65, and HN-40-45.

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² See <www.sjp.buaa.edu.cn/chinese/news1/html/20091015162957.html>. Alumni class notes, Harbin Institute of Technology Web site, posted on November 26, 2005, available at <<http://today.hit.edu.cn/articles/2005/11-26/11125423.htm>>.

³ Liu Xinge [刘昕戈], "Beijing Institute of Technology School of Automation and the 33rd Institute of the Third Research Institute of the China Aerospace Science and Industry Group Sign Cooperation Agreement" [北京理工大学自动化学院与中国航天科工集团第三研究院第三十三研究所签署合作协议], Beijing Institute of Technology Web site press release, available at <www.bit.edu.cn/xxgk/xysz/zdhxy/51521.htm>.

Table B.2. CASIC Facilities

Entity Name	Affiliation	Type, Area	Location	Description
China Aerospace Corporation (3 rd Academy, as detailed above)		Corporation, Design and Manufacturing		LACM guidance/navigation systems, complete CMs
Beijing Institute of Automatic Control Equipment (CASIC 33 rd RI) 北京自动化控制设备研究 (航天科工集团三院三十 三所)		Research Institute, R&D	Beijing	Research on automatic control systems, development of CM automatic flight control systems, “slow devices,” and inertial navigation systems
Beijing Institute of Mechanical Equipment 北机械设备研究所	中国长峰机电技术研究设计院 (航天二院)	Research Institute, R&D	Beijing	Development of launchers and other ground equipment
Beijing Institute of Electromagnetic Engineering (3 rd DD)		Research Institute, Design	Beijing	ASCM/LACM design and systems engineering
Power Machinery Research Institute (31 st RI)	中国海鹰机电技术研究院	Research Institute, R&D		Research of CM propulsion systems
Jinhang Institute of Computing Technology (8357 th RI)		Research Institute, R&D	Tianjin	Development of CM control systems and on-board computer systems
Beijing Special Machinery Institute (8359 th RI)		Research Institute, R&D	Beijing	Development of CM launching equipment
Beijing Hangxing Machine Building Factory		Factory	Beijing	Assembly of CMs
119 Factory		Factory	?	Autopilot systems
Third Academy/China Haiying Electromechanical Technology Academy (CHETA) 中国海鹰机电技术研究院	CASIC	R&D and manufacturing		ASCMS and ASCM-based TV-guided land-attack cruise missiles (LACMs)

Table B.3. Other Chinese Cruise Missile–relevant Organizations

Entity Name	Affiliation	Type, Area	Location	Description
Beijing Institute of Technology 北京理工大学	Ministry of Industry & Information	University, R&D	Beijing	Department of Automation Control researches weapon control systems, navigation systems
National University of Defense Technology 国防科学技术大学	Ministry of Defense & Ministry of Education	University, R&D	Changsha, Hunan	Ring Laser Laboratory and Dept. of Automatic Control develop navigation systems (target recognition), military scientist education and training
Shanghai Jiaotong University 上海交通大学	Ministry of Education	University, R&D	Shanghai	Thin Films and Micro-fabrication Laboratory develops flexible micro-gyroscopes, military electronically-controlled gyroscopes
China Electronics Technology Group Corporation 中国电子科技集团公司	Formerly under the now-dissolved Ministry of Information Industry	R&D; Manufacturing	Beijing	Defense-related electronics
Research and Design Institute of Shanghai Astronautics Automatic Control Equipment (812 th RI) 上海航天局自动控制设备设计研究所	Shanghai Municipal Government	Research Institute, R&D	Shanghai	Development of missile control systems and major components, produces inertial navigation systems
Shanghai Institute of Microsystems and Information Technology 中国科学院上海微系统与信息技术研究所 (上海微系统所)	Chinese Academy of Sciences	Research Institute, R&D	Shanghai	Research in micro-electronics, micro-gyroscopes, micro-sensors
Xi'an Institute of Applied Optics 西安应用光学研究所 (中国兵器工业集团公司第205研究所)	China Ordnance Industry Corporation	Research Institute, R&D	Xi'an, Shaanxi	Subsidiary of the China Ordnance Industry Corporation, researches optoelectronic systems, maintains a journal about image processing, image stabilization, targeting stabilization

Entity Name	Affiliation	Type, Area	Location	Description
Aerospace Times Instrument Corporation 航天时代仪器公司	CASC	Corporation, R&D/Manufacturing	Beijing; Xi'an, Shaanxi; Baoji, Shaanxi	Subsidiary of China Aerospace Science and Technology Corporation, researches/designs/manufactures inertial technology for tactical weaponry and missiles, navigation systems
Lanzhou Flight Control Instrument General Factory 兰州飞控仪器总厂	AVIC	Corporation, Development and Manufacturing	Lanzhou, Gansu	Development and manufacture of flight control systems for unmanned helicopters
Shaanxi Dengta Machinery Factory 陕西灯塔电机厂	CASC	Corporation, Development and Manufacturing	Baoji, Shaanxi	Development and manufacture of missile inertial navigation devices, direction finding equipment, radar systems
Shaanxi Huayan Aero-Instrument Company 陕西华燕航空仪表公司	AVIC	Corporation, Development and Manufacturing	Hanzhong, Shaanxi	Development and manufacture of gyroscopes, inertial instruments for military aviation, aerospace, weapons
Flight Automatic Control Research Institute 中国航空工业总公司飞行自动控制研究所	AVIC	Research Institute, R&D	Xi'an, Shaanxi	Development of flight control, navigation systems, produces digital flight control systems, UAV guidance systems
Hongdu Aviation Industry Group (formerly known as China Nanchang Aircraft Manufacturing Company) 江西洪都航空工业股份有限公司	AVIC	Corporation, Manufacturing	Nanchang, Hunan	Feilong ("Flying Dragon") series of ASCMs
China National South Aeroengine Company (formerly known as the Zhuzhou Aeroengine Factory)	AVIC		Zhuzhou, Hunan	Turbojet engines for ASCMs

Entity Name	Affiliation	Type, Area	Location	Description
Cruise Missile Institute of China (formerly Hai Ying EMT Academy)		Research Institute, R&D		Design of Hai-Ying (Silk-worm) CMs Models 1–4

Appendix C

Performance Parameters of Major Chinese Cruise Missiles¹

Type	Manufacturer	Launch Platform	Range (km)	Payload (kg)	Speed	Guidance
Antiship Cruise Missiles (ASCMs)						
SY-1 (CSS-N-1 "Scrubbrush" / SS-N-2A "Styx") ²	Nanchang Aircraft Factory (Hongdu Aviation Industry Corp)	Ship, ground	85	513	Subsonic	Inertial/active terminal guidance
SY-2 ³	Nanchang Aircraft Factory	Ship, ground	50	365	Subsonic	Inertial/active terminal guidance
HY-1 (CSS-N-2 "Safflower" / CSSC-2 "Silkworm") ⁴	CASIC Third Academy	Ship, ground	40	454	Subsonic	Inertial/active terminal guidance
HY-2 (CSS-N-3/ CSSC-3 "Seersucker") ⁵	CASIC Third Academy	Ship (Luda DD; Jianghu FF, Huangfen FAC), ground	95	454	Subsonic	Inertial/active terminal guidance
YJ-6 ⁶ (retired)	CASIC Third Academy	Air	110	513	Subsonic	Inertial/active terminal guidance
YJ-7 (C-701) ⁷	CASIC Third Academy	Ship, air, ground	25	30.5	Subsonic	Electro-optical/ active radar
YJ-62 (C-602) and YJ-62A ⁸	CASIC Third Academy	Ship, <i>Luyang II</i> , ground	280 400 (YJ-62A)	210	Subsonic	Inertial/active terminal guidance
YJ-8/8A (CSS-N-4 "Sardine" / C-801) ⁹	CASIC Third Academy	Ship, submarine (YJ-82), air (YJ-81)	42	165	Subsonic	Inertial/active terminal guidance

Type	Manufacturer	Launch Platform	Range (km)	Payload (kg)	Speed	Guidance
YJ-83 (CSS-N-8 “Saccade”/C-802) multiple variants ¹⁰	CASIC Third Academy	Ship, ground, air	120 (ground/ship), 130 (air)	165	Subsonic	Inertial/active radar
YJ-83A/J (C-802A) multiple variants ¹¹	CASIC Third Academy	Ship, ground, air	180 (ground/ship), 250 (air)	165	Subsonic	INS, datalink, active/passive radar
YJ-91/KR-1 (Kh-31P) ¹²	Zvezda-Strela, Russia; indigenized by China	Air (PLAAF/PLAN)	15–120	87–90 kg HE blast/fragmentation	Supersonic	Passive/anti-radiation
AS-13 “Kingbolt” (Kh-59MK) ¹³	Raduga, Russia	PLAAF Su-30MKK	45–115	320 kg AP HE or 280 kg cluster	Subsonic	Inertial and TV/electro-optical
SS-N-22/Sunburn 3M80E Moskit; 3M80MVE (improved variant) ¹⁴	Raduga (Russia); licensed production and improvements by CASIC?	Ship; Project 956 <i>Sovremenny</i> destroyers; 3M80MVE on Project 956EM <i>Sovremenny</i> destroyers	160–240 (3M80MVE)	300	Supersonic	INS/data link/active/passive
SS-N-27B/Sizzler ¹⁵	Novator (Russia)	Submarine—Kilo Project 636M	200	200	Supersonic	INS/active
CH-SS-NX-13 ¹⁶		Submarine—Song, Yuan, Shang, to be deployed on <i>Tang</i> ¹⁷	?	?	?	?
Land-attack Cruise Missiles (LACMs)						
YJ-63/KD-63 ¹⁸	CASIC Third Academy/CHETA	Air (H-6H bomber)	200	500	Subsonic	INS/sat(?) /passive; electro-optical terminal guidance
DH-10/CJ-10 ¹⁹		Ship (2 canister), ground (3 canister) ²⁰	1,500+	500	Subsonic	INS/TERCOM/probable DSMAC for terminal guidance
KD-88 ²¹		Air	180–200	165	Subsonic	Inertial; active terminal guidance
YJ-100 ²²		Air	1,500–2,000	500	Subsonic	INS/TERCOM
Possible “DH-2000” ²³		Submarine	?	500	Subsonic	?
YJ-91/KR-1 (Kh-31) ²⁴	Zvezda-Strela, Russia; indigenized by China	Ship, air (PLAAF/PLAN)	15–120	87–90 kg HE blast/fragmentation	Supersonic	Passive/anti-radiation
AS-13 “Kingbolt” (Kh-59MK) ²⁵	Raduga, Russia	PLAAF Su-30MKK	115	320 kg AP HE or 280 kg cluster	Subsonic	Inertial and TV/electro-optical

Sources

¹ This table draws in part on data from Andrew S. Erickson, “China’s Modernization of Its Naval and Air Power Capabilities,” in *Strategic Asia 2012–13: China’s Military Modernization, Regional Stability, and U.S. Extended Deterrence*, ed. Ashley J. Tellis and Travis Tanner, 60–125 (Seattle: National Bureau of Asian Research, 2012).

² “Anti-Ship Missiles” [反舰导弹], *S&T Daily*, September 24, 2009, available at <www.stdaily.com/special/content/2009-09/24/content_109031.htm>.

³ “CSS-N-1 ‘Scrubbrush’ (SY-1/HY-1/FL-1); CSS-N-2 ‘Safflower’ CSSC-2 ‘Silkworm’; CSS-N-3/CSSC-3 ‘Seersucker’ (HY-2/FL-3A),” *Weapons: Naval 2013, Jane’s Naval Weapons Systems*, February 12, 2012; Shirley Kan, *China: Ballistic and Cruise Missiles* (Washington, DC: Congressional Research Service, August 10, 2000), available at <www.carnegieendowment.org/pdf/npp/CRSchinamissilesupdated081000.pdf>.

⁴ Ibid.

⁵ Ibid.

⁶ Kan.

⁷ “C-701 (Kosar 1/3)/C-701AR (Zafar),” *Jane’s Naval Weapon Systems*, February 4, 2012.

⁸ The YJ-62 is a second-generation variant of the YJ-6 ASCM. “CSS-N-4 ‘Sardine’ (YJ-8/C-801); CSS-N-6 (YJ-83/C-802/Noor); YJ-62/C-602; YJ-82; CY-1,” *Jane’s Naval Weapon Systems*, August 31, 2012; OSD, *China Military Report 2012*, 21; OSD, *China Military Report 2011*, 2; and OSD, *China Military Report 2010*, 2; “China’s New Missile Deployment Being Monitored: Defense Minister,” *Central News Agency* (Taiwan), November 17, 2008, available at <www.globalsecurity.org/wmd/library/news/taiwan/2008/taiwan-081117-cna01.htm>.

⁹ The YJ-8 series ASCM has been in service on PLA Navy surface vessels for more than 20 years. See “CSS-N-4 ‘Sardine,’” See also “First Publicly-Released Photo of the YJ-82 Submarine-Launched Missile,” *China Defense Blog*, November 30, 2010, available at <http://china-defense.blogspot.com/2010/11/first-public-release-photo-of-yj-82.html>.

¹⁰ “CSS-N-4 ‘Sardine.’”

¹¹ The YJ-83A is a third variant of the basic YJ-8 ASCM (the export designation is C-802A). See OSD, *China Military Report 2012*, 21; and OSD, *China Military Report 2010*, 3. See also Bill Gertz, “Chinese Missile Has Twice the Range U.S. Anticipated,” *The Washington Times*, November 20, 2002, A03. The air-launched version is sometimes referred to as the YJ-83AK. *Jane’s* mistakenly refers to this variant as the C-803. For specific performance parameters, see “C-801 (CSS-N-4 ‘Sardine’/YJ-1/-8/-81), C-802 (CSSC-8 ‘Saccade’/YJ-2/-21/-22/-82/-85), and C-803 (YJ-3/-83/-88),” *Jane’s Strategic Weapon Systems*, February 7, 2012.

¹² The YJ-91 is based on the Russian Kh-31P. See OSD, *China Military Report 2011*, 30; and OSD, *China Military Report 2010*, 30. For performance parameters, see also “Yingji-91 (Kh-31P) Anti-Radiation Missile,” *China’s Defence Today*, October 20, 2008, available at <www.sinodefence.com/airforce/weapon/kh31.asp>.

“YJ-91, KR-1 (Kh-31),” *Jane’s Air-Launched Weapons*, March 7, 2012.

¹³ “Kh-59M, Kh-59ME Ovod-M (AS-18 ‘Kazoo’),” *Jane’s Air-Launched Weapons*, March 7, 2012.

¹⁴ OSD, *China Military Report 2012*, 21; OSD, *China Military Report 2011*, 2; and OSD, *China Military Report 2010*, 2.

¹⁵ Ibid.

¹⁶ No Chinese designation has been identified yet, and the missile still appears to be in development. See OSD, *China Military Report 2011*, 4; and OSD, *China Military Report 2010*, 3.

¹⁷ Ibid.

¹⁸ OSD, *China Military Report 2011*, 30; and OSD, *China Military Report 2010*, 31; *Ballistic and Cruise Missile Threat* (Wright-Patterson Air Force Base, OH: National Air and Space Intelligence Center, April 2009); and “KongDi-63 Air-Launched Land-Attack Cruise Missile,” *China’s Defence Today*, October 20, 2008, available at <www.sinodefence.com/airforce/weapon/kd63.asp>.

¹⁹ OSD, *China Military Report 2011*, 2; and OSD, *China Military Report 2010*, 31.

²⁰ Currently testing on *Dahua* (Hull 892).

²¹ OSD, *China Military Report 2012*, 21, 42; OSD, *China Military Report 2011*, 30; and OSD, *China Military Report 2010*, 31; “KD-88,” *China’s Defence Today*, October 26, 2008, available at <www.sinodefence.com/airforce/weapon/kd88.asp>.

²² Chen Wen-cheng [陳文政], “Defense Turning Back” [國防, 向後轉], *New Century Foundation Think Tank Quarterly* 46 [新世紀智庫論壇] (June 30, 2009), 14–17, available at <www.taiwanncf.org.tw/ttforum/46/46-04.pdf>. Chen Wen-cheng is former senior advisor for Taiwan’s National Security Council. The YJ-100 designation for the air-launched variant of the DH-10 has also been included in MND briefings.

²³ Tseng Fusheng [曾復生], “America Considers Communist China’s ‘Counter-Intervention Strategy’” [美因應中共(反介入戰略)的思維], National Policy Foundation National Security Brief, June 17, 2010, available at <www.npf.org.tw/post/3/7677>.

²⁴ The YJ-91 is based on the Russian Kh-31P. See OSD, *China Military Report 2011*, 30; and OSD, *China Military Report 2010*, 30; “YingJi-91 (Kh-31P) Anti-Radiation Missile,” *China’s Defence Today*; “YJ-91, KR-1 (Kh-31),” *Jane’s Air-Launched Weapons*, March 7, 2012.

²⁵ “Kh-59M, Kh-59ME Ovod-M (AS-18 ‘Kazoo’),” *Jane’s Air-Launched Weapons*.

Appendix D

Excerpts Pertaining to Cruise Missile Employment and Defense from Chinese Doctrinal Textbook

All excerpts are drawn directly from Zhang Yuliang [张玉良] et al., eds., *Science of Campaigns* [战役学] (Beijing: National Defense University Press [国防大学出版社], 2006). This operationally and tactically focused doctrinal textbook was published by China's National Defense University in 2000 and 2006 editions. The 2006 version appears to be significantly more sophisticated than its predecessor. It devotes additional focus to joint operations and the specific measures necessary to support offensive operations in order to deter other militaries from threatening China; or, failing that, to retaliate and compel them to retreat.

Chapter 12: The Joint Blockade Campaign [联合封锁战役], 292-309

Firepower Blockade [(3) 火力封锁] (305)

The firepower blockade consists of the implementation of firepower control with conventional guided missiles and other remote warfare directed at enemy ports and shipping lines, deterrence of the enemy fleet from entering or exiting the port, annihilation of enemy transport ships and anti-blockade forces, and a method to seal off enemy ports and sever the navigational routes close by. (305)

When the enemy transport fleet on the sea or in the air directs a penetration from open water toward the ports or directs a penetration from the ports toward the open water under cover, the campaign commander should: judge the hour and size up the situation; strive hard for the initiative; promptly confirm the enemy shipping lines and whether it is possible for the enemy to circumvent the channel; instruct the blockade forces that have already unfolded onto the sea and into the air in implementing active interception (积极拦击); organize the aviation and submarines as well as partial guided missile ships to grab hold of beneficial timing opportunities; and select beneficial sea areas, taking enemy transport shipping vessels as the main targets and carrying out multi-layered attacks. Based on strategic need, [the commander] can also: make use of campaign tactical missiles and long-range aviation forces; make sudden attacks against bases, loading and unloading and transport ports situated in the direction of the enemy penetration as

well as traffic arteries on the ground; and resolutely crush the intentions of the enemy to penetrate using enemy escort convoys. (306)

Implementing Monitoring, Boarding, Seizure and Attacks on the Sea [(3) 实施海上监控、临检、拿捕和攻击] (306)

When ships that are hostile to our side are discovered entering the sea blockade area, those other than ships that enjoy special protection, the sea blockade forces should promptly and resolutely be allowed to arrest or strike them. Targets for seizure are mainly unescorted merchant ships (无护航的商船); this activity is carried out in a wider sea area by the surface ship forces. It is permissible to destroy the ships that are difficult to send back to port once they have been stopped and seized on the water. Attacking ships whose activities are in violation of the blockade within the blockaded area is mainly the duty of submarines and aviation forces as well as surface guided missile vessel forces. Submarine forces typically apply positional ambush (阵地伏击) and area roving search (区域游猎) methods, covertly and suddenly carrying out attacks; aviation forces typically form an integrated, multiple aircraft, aerial formation with early warning, assault, covering, and support aircraft, that covertly closes with the enemy and implements multidirectional and multiple wave attacks; and water surface guided missile ship forces typically implement guided missile strikes in advantageous sea areas in multiple directions and at long distances following the aviation forces, or independently implement guided missile strikes against ships that violate the ban. (307)

Chapter 13: Amphibious Landing Campaigns [登岛战役], 310-330

The first strike is the most critical strike activity among the advance integrated firepower strikes, and is jointly executed mainly by a missile strike group and an air operations group. Its main missions are: by use of surprise, fierce, continuous firepower, to execute comprehensive and key-point paralysis and suppression of the enemy's major targets, and to the maximum extent, to weaken the enemy's operational capability so as to create favorable conditions for later strike activities. The first strike's major targets are vital targets: the enemy's military and political heads and staffs, electronic warfare (EW) centers, Air Force bases, naval bases, air defense system, and surface-to-surface missile positions. The first strike must be fully prepared, be launched stealthily and suddenly, and strive at the first opportunity to restrain the enemy. Before the strike, the campaign tactical missiles, high-performance operational aircraft, and other elite forces participating in the strike activities must be scientifically organized into groups, and missions rationally assigned to them, so as to magnify the first-strike effects. During the strike, usually with the cooperation of electronic suppression activities, one carefully coordinates the fire-

power of the missile forces and the aviation forces, so as to execute a concentrated strike of high intensity and high density; correctly selects the strike methods on the basis of the target conditions and strike goals; determines the number of attack waves based on actual requirements; unifies, coordinates, and carefully plans to ensure the continuity of firepower; and adopts all effective measures to restrain the enemy at the first opportunity and to take the initiative. Once the goals are achieved, which means one has not lost the opportunity to command the forces in execution of the follow-on strikes, one expands the first strike's effects, and achieves the goal of greatly reducing the enemy's operational capability. (318)

Chapter 14: Anti Air Raid Campaign [反空袭战役], 331-350

Air Raids Are Destructive, Making It Difficult to Protect Targets [(4) 空袭破坏性大，目标防护困难] (333)

With the widespread application of high technology in the aviation sphere, numerous precision guidance munitions such as cruise missiles, laser guided bombs, fuel-air explosives, graphite bombs, and electromagnetic bombs continue to emerge, which increase the accuracy and destruction of the air strike a great deal. It is reported that the hit probabilities of cruise missiles, anti-radiation missiles, and laser guided bombs are 75%, 87%, and 86%. (333)

Concentrate Strength and Apply Force with Key Points [(4) 集中力量，重点用兵] (337)

To concentrate strength means to strike vital targets or crucial parts that will influence the course and outcome of campaigns the most. In resistance operations, we need to apply force with key points to strike the enemy airborne early warning aircraft, electronic jammers, precision guided munitions carried on the aircraft, and cruise missiles, and damage the entire structure of air raids. (337)

Construct an Integrated Intelligence Early Warning System [(1) 构建一体化情报预警系统] (339)

In order to smoothly implement anti-air raid campaigns, we should establish an integrated intelligence early warning system in the land, sea, air, and space spheres to ensure that command institutions and forces at each level can promptly and accurately grasp the dynamic state of the enemy air raids. First, we need to establish an integrated air-space strategic early warning information system. In order to provide early warning for ballistic and cruise missile attack, we should have a deployment of skywave OTH radar, balloon-borne radar, bistatic/multistatic radar, phased array radar, passive radar, and

strategic infrared early warning satellites to form a strategic intelligence early warning system based on air defense early warning and space defense early warning. (339)

Closely Monitor the Dynamic State of Enemy Air Raids and Immediately Issue Air Raid Alarms [(3)

严密监视敌空袭动态，及时发出空袭警报] (340)

We should apply all kinds of reconnaissance and early warning means in the land, sea, air, and space spheres, have continuous and strict reconnaissance and surveillance for the air raid enemy, and immediately investigate the enemy air raid situation. From the enemy frequent reconnaissance activities, the unusual changes of radio communications, electronic jamming key point areas and intensity, and the exercises and transfers of air raid forces and weapons, we need to investigate the following as early as possible: the composition and number of enemy air raid forces, the air raid intention and scale, the air raid weapon bases, missile launch bases, and naval cruise missile launch platforms. (340)

Resistance Operations [(3) 抗击作战] (343)

The farthest intercept area is located in the front of the enemy air raid operational battlefield. It is the area where the fighter aviation force resists the enemy. The high performance interceptors and long-range SAMs are deployed in the area. In order to expand the intercept range, the interceptors and SAM units should be disposed forward as much as possible. In the coastal direction, we try to depend on the SAM force disposed on protruding sections of shore and near-shore islands and send out the naval ships with more powerful air defense firepower to move the intercept area to the sea as much as possible. When the enemy aircraft launch air raids, the interceptors in the forward airbase rapidly take off to intercept the enemy aircraft and cruise missiles with the coordination of long-range SAMs and air defense firepower of naval surface ships. (344)

Air route ambush. According to the activity laws of the enemy air raid weapons, part of the air defense force is ambushed on the flight route of the enemy air raid weapons, waiting for an opportunity to annihilate the enemy. The ambush sites are usually close to enemy aircraft route checkpoints, ASM launch positions, cruise missile routes, and the space domain of enemy airborne early warning aircraft, air-to-air tanker aircraft, and electronic jammers. (345)

Concentrate Strengths and Resist with Key Points [(3) 集中力量，重点抗击] (346)

Stealth aircraft and cruise missiles are the enemy long-range precision strike weapons with the best penetration capability. Therefore, these “three aircraft and one missile” should become our key-point strike targets in resistance operations. (346)

Strike enemy cruise missiles. The cruise missile usually takes low-altitude penetration, making it difficult for us to detect and track. However, its velocity is slow, flight time is long, and air route is fixed, and it will not maneuver after being attacked. This creates favorable conditions for us to intercept. In order to strike the enemy cruise missiles, we should first apply multiple means such as reconnaissance satellites, radars, laser, infrared, acoustics, and vision to grasp the whereabouts of the enemy cruise missiles. Second, according to the activity laws of enemy cruise missiles, we can set up defense with key points and intercept level by level. The flight route of enemy cruise missiles is more fixed so that we can roughly figure out the direction of cruise missiles based on the launch platform of enemy cruise missiles and the targets that the missile may strike and deploy air defense weapons. When the enemy launches a cruise missile attack, our interceptor in air patrol will intercept cruise missiles right away and the ground air defense force will organize a multichannel, multibelt, and multilevel fire network to intercept cruise missiles level by level. (347)

First, the missiles lead the way and integrate jamming with deception. When the enemy has a compact air defense system, we should concentrate fire assault in the first sortie against the enemy air force bases and strive to suppress the enemy airfield runways and air defense system effectively now that conventional missiles and cruise missiles have strong penetration capability and a long strike range, and the weather and climate conditions have little influence on the missiles. In the meantime, we should use unmanned electronic jammers and unmanned attack aircraft to implement strong electronic jamming and deceptive attack against the enemy air force bases, force the enemy air defense system to unfold and go into operations in advance, find out the tactical technical indices of the enemy air defense system, use antiradiation unmanned aerial vehicles to attack the enemy early warning radar system, and create conditions for aviation force penetration thereafter. (348)

Chapter 17: Mountain Offensive Campaigns [山地进攻战役], 404–425

Electromagnetic blocking and dividing [(6) 电磁遮断割裂] (424)

The methods of electronic blocking and dividing include the following. The first is electronic jamming and blocking. That is, we use jamming equipment on the ground to create a jamming zone and implement ground electromagnetic blocking; and we use jamming equipment in the air and at sea (coastal mountains) to implement air and sea electronic blocking. This way we create effective multidimensional electromagnetic blocking. The second method is to actually destroy the enemy's information system. That is, we use various types of firepower including antiradiation missiles, antiradiation UAVs, electromagnetic

pulse bombs, etc. to implement actual destruction of the enemy's important information systems in order to sever the enemy's communications, cause breakdown of their command system, and disrupt their troops' activities. The third method is to damage nodes. That is, we employ special operations troops to enter deep into the enemy rear. Through "hard" attack and "soft" destruction of the enemy's important information systems and facilities, we cause their normal operations to break down so as to divide and separate the enemy's command control system. (424)

Chapter 14: Offensive Campaigns against Coral Island Reefs [对珊瑚岛礁进攻役], 535–538

No mention of "cruise missiles" or "missiles."

Chapter 26: Naval Base Defense Campaigns [海军基地防御战役], 547–556

Resisting the Enemy's Sea/Air Raids. [(2) 抗敌海空袭击] (552)

When resisting the enemy's sea/air surprise attacks . . . the basic requirement is to concentrate firepower strikes against the highest-threat targets, such as aviation forces carrying air-to-ground missiles or ships carrying cruise missiles—these must be annihilated at any cost. (552)

Part Five: Air Force Campaigns

The Airspace of the Campaign Operations is Exceedingly Broad [(4) 战役作战空间十分广阔] (560)

Air-to-ground missiles and air-fired cruise missiles (空射巡航导弹) can implement precision strikes at distances over 100 kms and even several thousand kms (560)

Chapter 28: Air Offensive Campaigns [空中进攻战役], 575–588

Organizing an information offensive. [(2) 组织信息进攻] (580)

The main means are as follows: (A) using antiradiation unmanned aerial vehicles (UAVs), antiradiation ballistic missiles, antiradiation cruise missiles, and airborne antiradiation missiles (ARMs) to execute antiradiation strikes on the enemy's important EM [electromagnetic] targets, such as early warning radar and missile guidance radar, and to cripple and blind the enemy's air defense system. (580)

Operations to Resist the Enemy's Air Counterattacks [(4) 抗敌空中反击作战] (586)

Ground interdiction. One may use some of the mid- to long-range SAMs in a protrusive (*qianshen*) disposition, to execute maximum-range interception of the enemy. Using the main ground-based air defense forces—centering on the enemy's main incoming direction and key-point guarded targets—one should establish a long/medium/short-range, high/medium/low-altitude integrated resistance disposition with key points; execute layer-by-layer interception of the attacking enemy aircraft; strive to annihilate the enemy aircraft before they can drop their bombs; and intercept the [enemy] cruise missiles outside the area of the guarded targets. (587)

Chapter 30: Air Defense Campaigns [防空战役], 602–615

Grasping the Enemy Air Raid's Dynamic State and Issuing Air Raid Alarms [(1) 掌握敌空袭动态, 发出空袭警报] (608)

From various signs—the enemy's conduct of reconnaissance activities, unusual changes in radio and signal communications, the initiation of jamming, and air raid troop movement conditions—they must as early as possible ascertain the enemy air raid circumstances. The main contents [of this intelligence] are as follows: the enemy air raid's force composition, numbers, air raid intention, and scale; the air raid arms' departure bases, missile launch positions, and sea-based cruise missile launch platforms; and the air raid's direction, strike opportunities, targets, and penetration means, as well as the air raid's route and flight altitudes. (608)

Resistance against the enemy's strike in depth on critical targets. [(2) 抗敌突击纵深重要目标] (610)

The enemy AWACS [airborne warning and control system] planes are the centers of gravity for their air formations' acquisition of information and command coordination, their electronic warfare aircraft are the main strength for executing EM suppression, and stealth aircraft and cruise missiles are the enemy's long-range precision strike weapons with the strongest penetration capability; hence, these “three [types of] aircraft and one [type of] missile” should become the targets for key-point strikes in resistance operations. (610)

Simultaneous application of multiple methods, and execution of counterattacks. [(3) 多法并举, 实施反击] (612)

Organizing a missile counterattack. A missile counterattack is primarily executed by the 2nd Artillery Corps' conventional missile and cruise missile units, as well as by the Army's

campaign tactical missile units. Under ordinary circumstances, a missile counterattack should lay stress on strikes against large, planar, fixed targets such as enemy airfields and C2 systems. When the missile counterattack is jointly executed with an air counterattack, the missile counterattack should be executed first, to suppress and destroy the enemy air defense system, so as to create conditions for the aviation forces' penetration. (613)

When the air counterattack is jointly executed with a missile counterattack, one should fully exploit the results of the missile strike, and organize air strike strengths to execute continued strikes and supplementary strikes on the predesignated targets, to further exploit the battle gains. (613)

Chapter 31: Introduction, 616–628

Conventional Missile Strike Campaign [(2) 常规导弹突击战役] (617)

Usually the Second Artillery conventional missile strike campaign is a major compositional part in a joint campaign, and under special situations, it can also be independently implemented. (617)

Unified Command and Centralized Use [(1) 统一指挥，集中使用] (621)

For a nuclear counterstrike campaign, the campaign activities must be strictly organized in accordance with the orders from the Central Military Commission (中央军委); [whereas the activities] in a conventional missile strike campaign must be in accordance with the orders from the higher-level authorities, through the unified command of the Second Artillery conventional campaign large formation commander (第二炮兵常规战役军团指挥员). Commanders at each level must: unify their plans under the general headquarters or under the joint campaign command institution; carry out operational activities such as campaign dispositioning, campaign camouflage, campaign support, campaign synchronization and campaign strikes; and ensure (保证) that the missile forces jointly form integrated supremacy (整体优势) with other campaign strengths. In order to guarantee unified command, a perfected campaign command hierarchy (完善的战役指挥体系) must be established; command relationships and responsibilities must be clarified; unified campaign plans (*jihua*) must be formulated; and advanced command measures must be adopted, all for operation under unified orders and strict controls. (622)

In order to fully exploit the operational effectiveness of missile weaponry, the use of campaign strengths must be centralized. (622)

Chapter 32: The Second Artillery Conventional Missile Assault Campaign [第二炮兵常规导弹突击战役], 629–636

The basic mission in a Second Artillery conventional missile assault campaign consists of: jointly implementing a land campaign with the army and air force campaign large formations, and strike strategic point targets (要害目标) within the enemy campaign depth; coordinating with the navy and air force large formations to implement sea blockades and island blockades, striking such important targets as enemy naval bases, ports, air bases, and the like, and capturing localized campaign sea dominance; implementing amphibious landing and counteramphibious landing campaigns with naval, air force, and army campaign large formations; jointly implementing air offensive campaigns with air force campaign large formations; striking enemy air fields, ground-to-ground missile forces, air defense systems, and other important targets; and capturing localized campaign air dominance. In addition, based on need, it can also be to satisfy other special operational missions (特殊的作战任务). (629)

Requirements [(2) 要求] (631)

Unified Command and Closely-Knit Coordination [(1) 统一指挥，密切协同] (631)

During the joint campaign, there are wide-ranging coordination relationships that exist between the Second Artillery conventional missile campaign large formation and the other campaign strengths from the various branches of the service; only if there is successful campaign coordination between [the missile forces] and the other branches of the service can it be possible to form comprehensive operational power (整体作战威力). (631–632)

Implementing the Missile Firepower Blockade [(3) 实施导弹火力封锁] (634)

The missile firepower blockade (导弹火力封锁) consists of preventing or destroying the maneuver and supply of enemy troops and materials by implementing a missile firepower assault of a lower intensity. The goal of the missile firepower blockade is typically to sabotage enemy ground-, air-, or ocean (or water)-maneuvering activities. The basic method for the missile firepower blockade consists of implementing missile firepower assault or firepower harassment attacks against important targets the enemy depends on for ground-, aerial-, or ocean- (or water-) based maneuvering. (634–635)

Notes

Executive Summary

¹ Liu Tonglin, Ni Yonghua, and Liu Yin [刘桐林, 倪永华, 刘愔], eds., *Cruise Missiles—The “Assassin’s Mace” in High-Tech Warfare* [高技术战争中的“杀手锏”巡航导弹] (Beijing: Military Arts Press [解放军文艺出版社], 2002), 1–9. The term assassin’s mace (杀手锏 or 撒手锏) is best translated in colloquial English as *silver bullet*. It is widely used in Chinese strategic studies literature. An intelligent discussion of this issue is found in an unpublished manuscript by Alastair Iain Johnston, “Towards Contextualizing the Concept of a *Shashoujian* (Assassin’s Mace),” Harvard University Faculty of Arts and Sciences, August 2002, available at <www.people.fas.harvard.edu/~johnston/shashoujian.pdf>. See also Jason E. Bruzdinski, “Demystifying *Shashoujian*: China’s ‘Assassin’s Mace’ Concept,” in *Civil-Military Change in China: Elites, Institutes, and Ideas After the 16th Party Congress*, ed. Larry Wortzel and Andrew Scobell, 309–364 (Carlisle, PA: Strategic Studies Institute, U.S. Army War College, 2004).

² These requirements would involve some ideally rapid means of assessing the damage caused by the missiles’ use, individually or in tandem with other attack systems. They need not be stealthy, but it is probably better for the launching platform if they are.

³ There are significant difficulties in hitting mobile targets with anything slower than a laser. This, more than any other operation, requires timely and accurate intelligence.

⁴ William Murray, *China’s Undersea Warfare: A USN Perspective* (Newport, RI: China Maritime Studies Institute, Naval War College, May 11, 2011).

⁵ See Richard D. Fisher, Jr., “China’s New Strategic Cruise Missiles: From the Land, Sea and Air,” *IntelliBriefs*, last modified July 23, 2005, available at <<http://intellibriefs.blogspot.com/2005/07/chinas-new-strategic-cruise-missiles.html>>. Russia promotes the sale of a family of cruise missiles (Klub-S) capable of being fired from 533 millimeter (mm) torpedo tubes including the ASCM 3M-54E1 and the LACM 3M-14E. E is for export. The LACM is Missile Technology Control Regime (MTCR)-compliant, so it is hard to believe that China has been denied the 3M-14E while receiving the ASCM companion. *Jane’s* claims that China has the Klub submarine-launched cruise missile (SLCM). An SLCM can be either an LACM or an ASCM. So it could well be the 3M-14E.

⁶ “The Klub Family/Klub S Klub N/91RE2; 91RE1; SS-N-27B (3M54TE; 3M54E); SS-N-30B (3M14TE; 3M14E)/Klub K/Klub U (Russian Federation), Surface-to-surface missiles,” *Jane’s Naval Weapon Systems*, last modified January 20, 2012.

⁷ It took the United States years to become proficient in LACM employment. China has just started to deploy its LACMs. The U.S. military began in the 1970s and stumbled at first in achieving the accuracy and effectiveness it sought, as indicated by comparative numbers and effects from Operations *Desert Storm* and *Iraqi Freedom*. Still, China’s order of battle and commitment to the LACM suggest growing confidence about what it can do either as a deterrent or as a fighting force.

⁸ While most media attention focuses on ever-increasing numbers of Chinese ballistic and, lately, cruise missiles facing Taiwan, missile launchers are also an important measure of potential effectiveness. The number of launchers limits salvo size, but whatever effects China hopes to create depend on many other factors as well. Missile inventory determines overall “throw weight” (minus what gets shot down, so salvo size retains some importance). Depending on the defense levels of the targets and the importance of preemption or surprise attack, context decides which variable is the most important.

⁹ Lin Changsheng [林长胜], *Modern Weapons and Equipment of the People's Liberation Army* [解放军的武器装备] (Mississauga, ON: Mirror Books [明镜出版社], 1996), 183–203.

¹⁰ Military organizations “learn by doing.” Combined arms operations are enormously challenging. There is nothing quite like a war to test just how good military organizations truly are, and the PLA has not engaged in a major war since the limited Sino-Vietnamese War of 1979.

Introduction and Overview

¹ Du Chaoping [杜朝平], “U.S. ‘Tomahawk’ Cruise Missiles—Path Blazers in Modern Warfare” [现代战争的开路先锋—美国‘战斧’巡航导弹], *Shipborne Weapons* [舰载武器] (February 2004), 50–70; Yuan Jun [袁俊], “Threat Characteristics of Modern Cruise Missiles and Their Impact on Combat” [现代巡航导弹的威胁特点及其对作战的影响], *Aerospace China* [中国航天] (January 1999), 39–42.

² See, for example, Andrew S. Erickson, “Beijing’s Aerospace Revolution: Short-Range Opportunities, Long-Range Challenges,” in *Chinese Aerospace Power: Evolving Maritime Roles*, ed. Andrew S. Erickson and Lyle J. Goldstein, 3–18 (Annapolis: Naval Institute Press, 2011).

³ Office of the Secretary of Defense (OSD), *Annual Report to Congress: Military and Security Developments Involving the People’s Republic of China 2011*, 2, available at <www.defense.gov/pubs/pdfs/2011_CMPR_Final.pdf>. Hereafter, this Department of Defense (DOD) annual report to Congress is referred to as *China Military Report*, followed by the year of publication.

⁴ Ibid., 2.

⁵ Cruise missiles can hug the ground but do not have to. The whole point of flying in low is to reduce the reaction time of the defender. This can also be achieved by coming in fast (or, even better, fast and low) or using stealth to reduce radar detection range. Each approach has pros and cons as well as an associated cost and technological risk.

⁶ Thomas G. Mahnken, *The Cruise Missile Challenge* (Washington, DC: Center for Strategic and Budgetary Assessments, 2005), 42.

⁷ Ibid., 43.

⁸ Most ASCMs do not fly at high altitudes though some of the supersonic ones go high and dive into the targets, but not at subsonic speeds.

⁹ Cruise missiles approach their targets from a low, head-on position whereas a ballistic missile approaches from overhead. A cruise missile’s target is thus set against an air background, facilitating detection. But lack of an overhead view of the target complicates target classification.

¹⁰ Ge Xinqing [葛信卿], *Research on Missile Combat Operations* [导弹作战研究] (Beijing: Liberation Army Press [解放军出版社], 2005), 53–65, 372–374.

¹¹ Several Chinese sources suggest that cruise missiles are wonderful weapons against a second rate power but, like carrier-based aviation, are too vulnerable to perform the same missions against a power with good air or point defenses. See, for example, Liu Tonglin, Ni Yonghua, and Liu Yin, eds., *Cruise Missiles*.

¹² See Guan Shiyi, Zhu Kun, and Song Fuzhi [关世义, 朱坤, 宋福志], “Some Issues Regarding Cruise Missile Systems” [关于飞航导弹体系的几个问题], *Tactical Missile Technology* [战术导弹技术] (March 2004), 1–10. The authors are all from the CASIC Third Academy’s cruise missile design and systems engineering department. Guan Shiyi distinguishes cruise missiles into two types: *feihang daodan* [飞航导弹], which tend to be shorter-range antiship missiles, and *xunhang daodan* [巡航导弹], which are longer-range and often incorporate mid-course guidance systems such as TERCOM. See Guan Shiyi [关世义], “Diversification in Cruise Missile Development” [向多极化发展的飞航导弹], *Missiles and Space Vehicles* [导弹与航天运载 技术] (June 2002).

¹³ Office of Naval Intelligence (ONI), *The People's Liberation Army Navy: A Modern Navy with Chinese Characteristics* (August 2009), 22, available at <www.fas.org/irp/agency/oni/pla-navy.pdf>.

¹⁴ William S. Murray, "Revisiting Taiwan's Defense Strategy," *Naval War College Review* 61, no. 3 (Summer 2008), 13–38; David A. Shlapak et al., *A Question of Balance: Political Context and Military Aspects of the China-Taiwan Dispute* (Santa Monica, CA: RAND, 2009), 31–51.

¹⁵ ONI, *The People's Liberation Army Navy*, 1.

¹⁶ OSD, *China Military Report 2011*, 29.

¹⁷ Ibid.

¹⁸ Yang Yi, Liu Ren, and Hu Lin [杨艺, 刘仁, 胡林], "Analysis of Terminal Aerial Defense Missile System's Combat Efficiency Against Cruise Missiles" [末端防空武器系统对巡航导弹的作战效能分析], *Modern Defense Technology* [现代防御技术] 36, no. 4 (August 2008), 11–14. For similar wording, see Zhang Dongyang, Zhang Peng, and Wang Fengshan [张东洋, 张鹏, 王凤山], "A Study of Sensor Network Optimization for Cruise Missile Defense Operation" [巡航导弹防御作战传感器组网优化研究], *Winged Missiles Journal* [飞航导弹] (February 2007), 56.

¹⁹ Zhao Jiandong and Zhao Yingjun [赵建东, 赵英俊], "The Key to 21st Century Air Defense—Anti-Missile Technology" [21世纪防空的关键—反导], *Winged Missiles Journal* [飞航导弹] (June 2007), 13.

²⁰ Ibid., 12.

²¹ See, for example, Song Fuzhi [宋福志], "Countering Aircraft Carriers: Cruise Missiles Better Than Ballistic Missiles" [对抗航母—巡航导弹优于弹道导弹], *Tactical Missile Technology* [战术导弹技术] 4 (July 2006), 9–15.

²² Liu Tonglin [刘桐林], *A Sharp Lance of Modern Naval Warfare—The Anti-ship Cruise Missile* [现代海战的利矛—反舰导弹] (Beijing: Military Science Press [军事科学出版社], 2003), 325.

²³ Lü Jiuming and Luo Jingqing [吕久明, 罗景青], "An Analysis of the Strong and Weak Points of Cruise Missiles and the Methods of Defense against Them" [巡航导弹强弱点分析及防御方法], *Fire Control & Command Control* [火力与指挥控制] 31, no. 2 (February 2006), 1–2.

²⁴ Wang Jin and Fu Qi [王瑾, 傅琦], "Pride and Prejudice: An Interpretation of Keating's Visit to China" [傲慢与偏见: 解读基廷访华], *Ordnance Knowledge* [兵器知识] (March 2008), 38–40.

Chapter One

¹ A definitive study of China's Cold War military industrial development offers the following summary: "Antiship missile production in China began at the end of the 1950s. Since then, several stages such as copy production of ship-to-ship missiles, operational improvements and derivation and independent design of coast-to-ship, and air-to-air missiles, development of the second generation of antiship missile have passed and technically it evolved from subsonic speed to supersonic speed, from liquid engine to solid engine and ram engine and from single guidance to combined guidance. The second generation of antiship missile was developed in the 1980s, the main operational and technical specifications of which were close to or reached the then world advanced level." Yu Yongbo et al., *China Today: Defence Science and Technology*, Vol. 2 (Beijing: National Defence Industry Press, 1993), 508.

² Sun Yali [孙亚力], "A Discussion on the Development of China's Surface-to-Air Missiles: An Interview with Surface-to-Air Expert Senior Colonel Wang Heping" [中国地空导弹发展访谈录—访地空导弹专家王和平大校], *Ordnance Knowledge* [兵器知识] (October 1998), 2–4; Xun Fu [巡抚], "Technology and Tactical Thinking in China's Early Days of Anti-Ship Missiles" [中国早期反舰导弹的技术与战术思想] *Modern Ships* [现代舰船] (March 2005), 36–43.

³ Yu Yongbo et al., *China Today: Defence Science and Technology*, Vol. 1 (Beijing: National Defence Industry Press, 1993), 422.

⁴ Lin Changsheng, *Modern Weapons and Equipment of the People's Liberation Army*, 185–188; Wang Wei [王伟], “A Preliminary Analysis of China's Anti-Ship Missiles” [浅析中国反舰导弹], *Shipborne Weapons* [舰载武器] (May 2008), 35; and Writers Group [“聂荣臻传”编写组], *The Biography of Nie Rongzhen* [聂荣臻传] (Beijing: Modern China Press [当代中国出版社], 2006), 331–336.

⁵ Iris Chang, *Thread of the Silkworm* (New York: Basic Books, 1995), 211–215.

⁶ Hai Chao [海潮], “Conventional Weapon Testing in China's Navy” [中国海军常规武器试验], *Shipborne Weapons* [舰载武器] (April 2005), 34–40.

⁷ Contemporary China Series Editorial Committee [“当代中国”丛书编委会], *China Today: Scientific and Technological Undertakings of National Defence* [当代中国的国防科技事业], Book Two [下卷] (Beijing: Contemporary China Press [当代中国出版社], 1992), 62–99; Sun Xu [孙旭], “The Shining Chinese Missiles” [中国导弹光彩夺目], *Contemilit* [现代军事] (March 1999), 19; Hai Chao [海潮], “China's Naval Conventional Weapons Tests (1)” [中国海军常规武器试验 (上)], *Shipborne Weapons* [舰载武器] (April 2005), 34–40; Evan S. Medeiros et al., *A New Direction for China's Defense Industry* (Santa Monica, CA: RAND, 2005), 82–86.

⁸ Luo Laiyong and Zhou Junlun [罗来勇, 周均伦], *Marshal Nie Rongzhen* [聂荣臻元帅] (Beijing: Military Arts Press [解放军文艺出版社], 2006); Writer's Group, *The Biography of Nie Rongzhen*; Tai Ming Cheung, “Innovation and Stagnation During the Maoist Era,” in *Fortifying China: The Struggle to Build a Modern Defense Economy*, 22–51 (Ithaca, NY: Cornell University Press, 2008).

⁹ Xun Fu [巡抚], “Technology and Tactical Thinking in China's Early Days of Anti-Ship Missiles” [中国早期反舰导弹的技术与战术思想], *Modern Ships* [现代舰船] (March 2005), 36–43; Li Ziyu [离子鱼], “On the Development of China's Air-to-Ship Missiles” [谈谈中国空射反舰导弹], *Shipborne Weapons* [舰载武器] (July 2006), 19–25.

¹⁰ Dennis M. Gormley, *Missile Contagion: Cruise Missile Proliferation and the Threat to International Security*, 16–27 (Annapolis: Naval Institute Press, 2010); *ibid.*, 47–65.

¹¹ Tai Ming Cheung, “Innovation and Stagnation During the Maoist Era,” in *Fortifying China*, 36–40.

¹² Shirley A. Kan, *China: Commission of Science, Technology, and Industry for National Defense (COSTIND) and Defense Industries*, Congressional Research Service (CRS) Report for Congress (Washington, DC: Library of Congress, December 1997); Harlan W. Jencks, “COSTIND Is Dead, Long Live COSTIND! Restructuring China's Defense Science, Technological, and Industrial Sector,” in *The People's Liberation Army in the Information Age*, ed. James C. Mulvenon and Richard H. Yang, 59–77 (Santa Monica, CA: RAND, 1999).

¹³ Tai Ming Cheung, “The Revival of the Defense Economy in the Twenty-first Century,” in *Fortifying China*, 101–175.

¹⁴ Timothy Hu, “A Morning Star Shines: China's Military Modernization,” Part Two, *Jane's Defence Weekly*, July 30, 2008.

¹⁵ *Ibid.*

¹⁶ Harlan W. Jencks, “The Chinese Military-Industrial Complex and Defense Modernization,” *Asian Survey* 20, no. 10 (October 1980), 966. For general surveys of China's defense industry, see David L. Shambaugh, “China's Defense Industry: Indigenous and Foreign Procurement,” in *The Chinese Defense Establishment: Continuity and Change in the 1980s*, ed. Paul H.B. Godwin, 43–86 (Boulder, CO: Westview Press, 1983); Bates Gill and Taeho Kim, “Lessons of History: 150 Years of Foreign Arms Acquisition,” in *China's Arms Acquisitions from Abroad*, 8–47 (New York: Oxford University Press, 1996); Ronald D. Humbe, “Science, Technology and China's Defense Industrial Base,” *Jane's Intelligence Review* (January 1992), 3–11; Wendy Frieman, “China's Defense Industry,” *The Pacific Review* 6, no. 1 (1993), 51–62; John Frankenstein, “The People's Republic of

China: Arms Production, Industrial Strategy and Problems of History,” in *Arms Industry Limited*, ed. Herbert Wulf, 271–319 (Oxford: Oxford University Press for SIPRI, 1993).

¹⁷ Eric Arnett, “Military Technology: The Case of China,” in *SIPRI Yearbook 1995: Armament, Disarmament and International Security*, 359–386 (Oxford: Oxford University Press, 1995); Evan S. Medeiros et al., 1–50.

¹⁸ Michael J. Barron, “China’s Strategic Modernization: The Russian Connection,” *Parameters* 31, no. 4 (Winter 2001/2002), 72–86; Vladimir Ivanov and Vladimir Shvarev, “China Needs Our Technologies: Beijing Sets Strategic Course of Acquiring Licenses and Own Production,” *Nezavisimaya Gazeta*, December 17, 2003.

¹⁹ Li Chenghong [李承红], “Sino-Russian Military Technology Cooperation: Current Status, Problems, and Responses” [中俄军事技术合作: 现状, 问题与对策], *Russian Studies* [俄罗斯研究] 1 (February 2009), 87–116; Jim Mann, “Russia Boosting China’s Arsenal,” *Los Angeles Times* (Washington edition), November 30, 1992, 1; Tai Ming Cheung, “China’s Buying Spree,” *Far Eastern Economic Review*, July 8, 1993, 24; John J. Fialka, “U.S. Fears China’s Success in Skimming Cream of Weapons Experts from Russia,” *The Wall Street Journal*, October 14, 1993, 12; John Pomfret, “China, Russia Solidifying Military Ties,” *The Washington Post*, February 10, 2000, 17; Meng-Yen Tsai, *From Adversaries to Partners?* (Westport, CT: Praeger, 2003).

²⁰ Dennis Van Vranken Hickey, *The Armies of East Asia: China, Taiwan, Japan, and the Koreans* (Boulder, CO: Lynne Rienner, 2001), 69–118.

²¹ Phillip C. Saunders and Joshua K. Wiseman, *Buy, Build, or Steal: China’s Quest for Advanced Military Aviation Technologies*, China Strategic Perspectives 4 (Washington, DC: National Defense University Press, December 2011), 36.

²² Timothy Hu, “A Morning Star Shines.”

²³ Evan S. Medeiros et al.

²⁴ Mark A. Stokes, *China’s Strategic Modernization: Implications for the United States* (Carlisle, PA: Strategic Studies Institute, U.S. Army War College, 1999), 79–86; Richard D. Fisher, Jr., “China’s New Strategic Cruise Missiles: From the Land, Sea and Air,” International Assessment and Strategy Center, June 3, 2005, available at <www.strategycenter.net/research/pubID.71/pub_detail.asp>.

²⁵ See Mark A. Stokes, *China’s Evolving Conventional Strategic Strike Capability: The Anti-Ship Ballistic Missile Challenge to U.S. Maritime Operations in the Western Pacific and Beyond* (Arlington, VA: Project 2049 Institute, September 14, 2009), 48, available at <http://project2049.net/documents/chinese_anti_ship_ballistic_missile_asbm.pdf>.

²⁶ Available at <www.hongdu.com.cn/yw/index.htm>.

²⁷ In 1999, Chinese defense industry reforms established 10 enterprise groups representing China’s five core defense sectors: nuclear, aviation, ordnance, shipbuilding, and aerospace. AVIC was split into two companies (AVIC I and AVIC II) to enhance competition in the aviation sector. Both Hongdu and South Aeroengine were placed under the newly established AVIC II, which was subsequently remerged with AVIC I in 2008. Evan S. Medeiros et al., 62–63; Harlan W. Jencks, “COSTIND Is Dead,” 59–74.

²⁸ “China Precision Machinery Import and Export Corporation,” company brochure, available at <www.nti.org/db/china/cpmiec.htm>.

²⁹ Ibid.

³⁰ Shirley A. Kan, *China and Proliferation of Weapons of Mass Destruction and Missiles: Policy Issues*, CRS Report for Congress, March 6, 2008, available at <www.fas.org/sgp/crs/nuke/RL31555.pdf>.

Chapter Two

¹ Order of battle data in this section draws in part on Andrew S. Erickson, “China’s Modernization of Its Naval and Air Power Capabilities,” in *Strategic Asia 2012–13: China’s Military Modernization, Regional*

Stability, and U.S. Extended Deterrence, ed. Ashley J. Tellis and Travis Tanner), 60–125 (Seattle: National Bureau of Asian Research, 2012).

² OSD, *China Military Report 2011*.

³ Robert Hewson, “Dragon’s Teeth—Chinese Missiles Raise Their Game,” *Jane’s Navy International* 112, no. 1 (January 2007), 19–23.

⁴ Murray explains that “The evidence for this important shift is admittedly circumstantial, but is fully coherent with the technology available to China; with the ASUW mission expected of PLAN tactical submarines; with the mode of ASUW adopted by the PLA surface navy, air forces and Second Artillery Corps; and with the relatively low amount of at-sea training conducted by Beijing’s submarines.” See Murray, *China’s Undersea Warfare*.

⁵ China began to deploy air-launched CM (YJ-6-Eagle Strike, also C-601) in 1987 to the air wing of the PLAN. See Li Ziyu, “On the Development of China’s Air-to-Ship Missiles,” 21; Lin Changsheng, *Modern Weapons and Equipment of the People’s Liberation Army*, 191.

⁶ Feng Huo [烽火], “Survey of Global Ship-Borne Cruise Missiles” [海基巡航导弹大扫描], *Modern Ships* [现代舰船] (April 2007), 36–39.

⁷ “CSS-N-4 ‘Sardine’ (YJ-8/C-801); CSS-N-6 (YJ-83/C-802/Noor); YJ-62/C-602; YJ-82; CY-1,” *Jane’s Naval Weapon Systems* (August 13, 2012).

⁸ “C-701 (Kosar 1/3)/C-701AR (Zafar),” *Jane’s Naval Weapon Systems* (May 2012); Xie Huiqing [谢慧清], “Chinese C-series Antiship Missiles under Rapid Development” [快速发展中的中国C字反舰导弹], *Shipborne Weapons* [舰载武器] (January 2008), 35–39; Xu Tong [许彤], “China’s C-701 Small-Sized Multi-Purpose Cruise Missile” [中国的C-701小型多用途飞航导弹], *Aerospace China* [中国航天] (September 1999), 42–44.

⁹ Unless otherwise specified, data in this paragraph is derived from *Jane’s*, “CSS-N-4 ‘Sardine.’”

¹⁰ For photographs and a guide to the YJ-8 variants, see Christopher P. Carlson, “China’s Eagle Strike—Eight Anti-Ship Cruise Missiles, Parts 1, 2, and 3,” (Washington, DC: Defense Media Network, February 4, 2013). Note that Carlson believes the PLA never deployed the C-802 and went straight to the 180 km variant, which he calls the YJ-83.

¹¹ OSD, *China Military Report 2011*; OSD, *China Military Report 2010*, 3; see also “First Publicly-Released Photo of the YJ-82 Submarine-Launched Missile,” *China Defense Blog*, available at <<http://china-defense.blogspot.com/2010/11/first-public-release-photo-of-yj-82.html>>.

¹² Unless otherwise specified, data in this paragraph is derived from *Jane’s*, “CSS-N-4 ‘Sardine.’”

¹³ *Ibid.*

¹⁴ Yao Shaofu and Liu Qingmei [姚绍福, 刘庆楣], “China’s C-802 Land AntiShip Missile System” [中国的C-802岸舰导弹武器系统], *Aerospace China* [中国航天] (July 1991), 39–42; Fang Zhang [方丈], “The Chinese Navy’s C-801, C-802 Multi-purpose AntiShip Missiles” [中国海军C801, C802多用途反舰导弹], *World Aerospace and Space Survey* [世界航空航天博览] (December 2003), 58–59; “The C-802 Makes a Surprise Attack on the ‘Hanit’” [C-802袭击‘哈尼特’], *Naval & Merchant Ships* [舰船知识] (August 2008), 37–39.

¹⁵ Unless otherwise specified, data in this paragraph is derived from *Jane’s*, “CSS-N-4 ‘Sardine.’”

¹⁶ According to *Jane’s*, “A version of this weapon has been developed by Iran with Chinese assistance as the Tondar (CSSC-8) coast-defence missile. The Iranians claimed to have deployed an improved, locally-made version of this weapon, Noor, for ship use in October 2000. They claimed the weapon to have a range of 108 n miles (200 km). Three Noor missiles (or C-802) were launched from land by Hezbollah forces on 14 July 2006. One detonated upon launch, the second damaged the Israeli corvette INS *Hanit*, exploding upon hitting a guardrail, and the other missed the frigate and . . . sank a merchantman some 32 n miles (60 km)

away.” See *Jane’s*, “CSS-N-4 ‘Sardine.’” For detailed analysis of the incident, see “The C-802 Makes a Surprise Attack on the ‘Hanit’” [C-802袭击‘哈尼特’], *Naval & Merchant Ships* [舰船知识] (August 2008), 37–39.

¹⁷ “C802A AntiShip Missile Weapon System,” China National Precision Machinery Import and Export Corporation, 2008, trade brochure.

¹⁸ *Jane’s*, “CSS-N-4 ‘Sardine’”; “CSS-N-8 ‘Saccade’ (YJ-83/C-802/YJ-83A/C-802A/Noor/Ghader), YJ-62/C-602,” *Jane’s Naval Weapon Systems*, August 13, 2012; “YJ-8K (C-801K), YJ-82K (C-802K/KD), C-802A and YJ-83, CM-802AKG,” *Jane’s Air-Launched Weapons*, March 28, 2011.

¹⁹ China National Precision Machinery Import and Export Corporation.

²⁰ *Jane’s*, “CSS-N-4 ‘Sardine’”; OSD, *China Military Report 2012*, 21; OSD, *China Military Report 2010*, 3. See also Bill Gertz, “Chinese Missile Has Twice the Range U.S. Anticipated,” *The Washington Times*, November 20, 2002, A03; “YJ-83,” *MissileThreat.Com*, undated, available at <www.missilethreat.com/cruise/id.67/cruise_detail.asp>. The air-launched version is sometimes referred to as the YJ-83K. For specific performance parameters, see *Jane’s*, “CSS-N-4 ‘Sardine’”; *Jane’s*, “CSSC-8 ‘Saccade.’”

²¹ Thomas G. Mahnken, *The Cruise Missile Challenge*, 15.

²² ONI, *The People’s Liberation Army Navy*, 27.

²³ “YJ-6 (C-601) CAS-1 ‘Kraken,’ YJ-61 (C-611),” *Jane’s Air-Launched Weapons*, March 28, 2011.

²⁴ ONI, *The People’s Liberation Army Navy*.

²⁵ *Ibid.*

²⁶ Scott Bray, Senior Intelligence Officer–China, ONI, statement obtained through ONI Public Affairs Office, November 2009.

²⁷ “China’s New Missile Deployment Being Monitored: Defense Minister,” *Central News Agency* (Taiwan), November 17, 2008, available at <www.globalsecurity.org/wmd/library/news/taiwan/2008/taiwan-081117-cna01.htm>.

²⁸ OSD, *China Military Report 2012*, 21; OSD, *China Military Report 2011*, 2; OSD, *China Military Report 2010*, 2.

²⁹ Ted Parsons, “China’s Navy Shores up Defences with Long-Range YJ-62C Missile,” *Jane’s Defence Weekly*, June 6, 2008; “CSS-N-1 ‘Scrubbrush’ (SY-1/HY-1/FL-1); CSS-N-2 ‘Safflower’ CSSC-2 ‘Silkworm’; CSS-N-3/ CSSC-3 ‘Seersucker’ (HY-2/FL-3A),” *Weapons: Naval 2013*, *Jane’s Naval Weapon Systems*, February 12, 2012.

³⁰ Chinese publications also suggest that in the mid-1990s, a SY-2A ship-to-ship missile was being developed with an extended range of 130 km. See Wang Wei [王伟], “Sharp Blade: Development of the PLA-Navy’s Anti-Ship Missiles” [利刃: 浅析中国反舰导弹], *Naval Weapons* [舰载武器] (May 2008), 37; see also “SY-2 AntiShip Missile,” *China Defence Today*, April 2006, available at <www.sinodefence.com/navy/navalmissile/sy2.asp>. *China Defence Today* is widely regarded as portraying accurate and factual data albeit from unknown sources.

³¹ OSD, *China Military Report 2012*, 21; OSD, *China Military Report 2011*, 2, 30; OSD, *China Military Report 2010*, 2.

³² ONI, *The People’s Liberation Army Navy*, 28.

³³ See “3M-54E (SS-N-27) AntiShip Cruise Missile,” *China Defence Today*, April 2006, available at <<http://web.archive.org/web/20080127224807/http://www.sinodefence.com/navy/navalmissile/3m54.asp>>.

³⁴ Unless otherwise specified, data for this paragraph is derived from “P-80/-270 Zubr/Moskit (SS-N-22 ‘Sunburn’/3M-80/3M82),” *Jane’s Strategic Weapon Systems*, September 4, 2009.

³⁵ See OSD, *China Military Report 2012*, 21; OSD, *China Military Report 2011*, 2; OSD, *China Military Report 2010*, 2.

³⁶ Thomas G. Mahnken, *The Cruise Missile Challenge*, 12.

³⁷ OSD, *China Military Report 2012*, 21; OSD, *China Military Report 2011*, 2; OSD, *China Military Report 2010*, 2.

³⁸ ONI, *The People's Liberation Army Navy*, 28.

³⁹ For 3M80MVE characteristics, see the Tactical Missiles Corporation Web site, available at <<http://eng.ktrv.ru>>.

⁴⁰ "Chinese Cruise Missiles," *World Outlook*, no. 492 (June 2004), 21.

⁴¹ *China Defence Today* states that China has the Kh-31P. See "Yingji-91 (Kh-31P) AntiRadiation Missile," *China's Defence Today*, October 20, 2008, available at <www.sinodefence.com/airforce/weapon/kh31.asp>.

⁴² "Kh-31 (AS-17 'Krypton')," *Jane's Strategic Weapon Systems*, September 4, 2009.

⁴³ Li Ziyu, "On the Development of China's Air-to-Ship Missiles," 24–25. See also, "Air-Launched Weapons," *Chinese Military Aviation* (June 2005), available at <<http://web.archive.org/web/20050309004857/http://mil.jschina.com.cn/huitong/missile.htm>>. The accuracy of this Web site cannot be corroborated in the scope of this paper. Weapons data are accompanied by pictures and acknowledge indiscernible sources.

⁴⁴ "Kh-59M, Kh-59ME Ovod-M (AS-18 'Kazoo')," *Jane's Air-Launched Weapons*, November 12, 2009. Air-to-surface missiles like the Kh-59 and Kh-31 variants discussed here are short-legged missiles whose success depends critically on the survival of their aircraft-delivery platforms in air-to-air battles and against SAM threats from both land and naval platforms.

⁴⁵ See also Miroslav Gyürösi, "Kh-59MK Refined to Meet Chinese Requirements," *Jane's Missiles and Rockets*, October 1, 2003.

⁴⁶ See "Air-Launched Weapons," June 2005.

⁴⁷ "Kh-59M, Kh-59ME Ovod-M (AS-18 'Kazoo')," *Jane's Air-Launched Weapons*, March 7, 2012.

⁴⁸ OSD, *China Military Report 2011*, 4; OSD, *China Military Report 2010*, 3.

⁴⁹ *Ibid.*, 4.

⁵⁰ Hong Zhiping [洪志平] and Hong Xing [洪星], "Calculation Model of Beyond-the-Horizon AntiShip Missiles Striking Surface Ship Formation," [超视距反舰导弹打击水面舰艇编队计算模型] *Information Command Control System & Simulation Technology* [情报指挥控制系统与仿真技术] 26, no. 2 (April 2004), 58–61.

⁵¹ Yao Xiaobai [姚晓白], "A New Algorithm of Necessary Missile Quantity in Antiship Missile's Saturation Attack" [反舰导弹饱和攻击所需发射导弹数量的一种新算法], *Tactical Missile Technology* [战术导弹技术] (July 2002), 17–21.

⁵² On saturation attacks and defense against them, see Walter L. Perry et al., *Measures of Effectiveness for the Information-Age on Combat Outcomes* (Santa Monica, CA: RAND, 2002), 15–66, available at <www.rand.org/pub/monograph_reports/MR1449>.

⁵³ This would entail comparing offense with offense when one should compare offense with defense.

Chapter Three

¹ In such industrial economies as India, Pakistan, South Korea, and Taiwan, long-range missiles could also be capable of delivering nuclear, biological, or chemical payloads.

² Adding satellite navigation to an LACM would transform it into a delivery system capable of achieving a circular error probable (CEP) of around 20 m or better, no matter what the missile's range. The accuracy of first-generation Scud ballistic missiles is between 1 and 2 km. Without sophisticated and costly maneuvering reentry or post-boost vehicles, these missiles can only use satellite navigation corrections until main engine cutoff, which occurs early in their flight sequence; accuracy improvements in this case would amount to only 20 percent at best. More advanced ballistic missiles such as those possessed by China incorporate separating payloads, which can, with satellite updates, achieve about a 70 percent improvement in accuracy. Further accuracy improvements are possible for ballistic missiles (such as costly and complex development of map-matching technologies), but they are far more costly for ballistic missiles than they are for cruise

missiles. See Gerald Frost and Irving Lachow, *Satellite Navigation-Aiding for Ballistic and Cruise Missiles*, RAND/RP-543 (Santa Monica, CA: RAND, 1996), 3–8.

³ RAND analysts calculate that to destroy a typical hangar on a Taiwan military airfield it would require two to three ballistic missiles possessing CEPs of 15 meters to achieve a 90 percent probability of success. With a 30 m CEP, that would require two to three times the number of missiles. See David A. Shlapak et al., *A Question of Balance* (Santa Monica, CA: RAND, 2009), 44–45.

⁴ While it would be wrong to draw equivalence between U.S. and Chinese cruise missile use, it is cheaper and easier to make LACMs more accurate than ballistic missiles. Rather than use LACMs to cut runways, China is more likely to employ them against small, possibly hard point targets. Here they complement each other well. As for the combined use of ballistic and cruise missiles, in the authors' experience, missile defenders worry most about adversaries acquiring both ballistic and cruise missiles because of the unique challenges defenders face. Militaries that have contemplated acquiring missile defenses (for example, Taiwan and South Korea) have purchased only very modest numbers because of the cost and have instead turned to offensive systems.

⁵ OSD, *China Military Report 2011*, 30.

⁶ Yitzhak Shichor, "Israel's Military Transfers to China and Taiwan," *Survival* 40, no. 2 (Spring 1998), 90.

⁷ U.S. Senate, Lieutenant General Ronald L. Burgess, Jr., USA, Director, Defense Intelligence Agency, "Annual Threat Assessment," Statement Before the Senate Armed Services Committee, February 16, 2012, available at <www.dia.mil/public-affairs/testimonies/2012-02-16.html>.

⁸ Li Chenghong, "Sino-Russian Military Technology Cooperation: Current Status, Problems, and Responses"; Wang Fei [王伟], "Sino-Russian Military Technology Cooperation under the Strategic Partnership" [中俄战略协作伙伴关系下的军技合作], *Russian, Central Asian and Eastern European Studies* [俄罗斯中亚东欧研究] (Issue 4, 2006), 62–68; "China's Missile Imports and Other Assistance from Russia," Nuclear Threat Initiative (NTI), China Profiles, Center for Nonproliferation Studies, Monterey Institute.

⁹ Stephen J. Blank, *The Dynamics of Russian Weapon Sales to China* (Carlisle, PA: Strategic Studies Institute, U.S. Army War College, 1977), 8.

¹⁰ *Ibid.*, 8. Blank notes that the source of this assertion was Chong-pin Lin, a Taiwan citizen who in 1995 was affiliated with the American Enterprise Institute in Washington, DC. Lin later served as Deputy Minister of National Defense in Taiwan and is now a professor at Tamkang University.

¹¹ Huang Shiqi, Liu Daizhi, and Chen Liang [黄世奇, 刘代志, 陈亮], "Research of Scene and Terrain Matching Guidance Based on SAR Imaging" [基于合成孔径雷达成像的景象与地形匹配制导研究], *Tactical Missile Control Technology* [战术导弹控制技术], no. 2 (2006), 46–49.

¹² W. Seth Carus, *Cruise Missile Proliferation in the 1990s* (Westport, CT: Praeger, 1992). The Government Accountability Office (GAO) also cites this figure in testimony before a House committee in March 2004. See Wade Boese, "GAO Says Feds Lax in Countering Cruise Missile, UAV Threats," *Arms Control Today*, available at <www.armscontrol.org/act/2004_04/GAO>.

¹³ Using the NATO naming system, technically the HY-1 received the name "Silkworm" while the HY-2 was named "Seersucker" when referring to the land-based coastal defense variant. NATO named the ship-to-ship variant of the HY-1 "Safflower." Technically, therefore, the name "Silkworm" should be limited to the HY-1, but analysts have come to refer to both the HY-1 and the HY-2 (and in some cases other Chinese ASCMs) as "Silkworm." This report adopts the more liberal naming of the missile.

¹⁴ For the YJ-63 (KD-63) Land-Attack Cruise Missile, see <www.sinodefence.com/airforce/weapon/kd63.asp>. Indeed, some reporting suggests that China used the turbojet-equipped HY-4, an improved version of the HY-2, as a test bed for the XW-41, which was transformed into an LACM with the addition of the GPS/GLONASS-aided inertial reference guidance system with a range of 300 km by 2002 and later became the YJ-63.

In this sense, the XW-41, based on the HY-4, became the test bed for the YJ-63. See <www.sinodefence.com/navy/navalmissile/hy4.asp>.

¹⁵ For useful background on the origins of these ASCMs, see “China: Offensive Weapons,” in Duncan Lennox, ed., *Jane’s Strategic Weapon Systems* (Coulsdon, Surrey: Jane’s Information Group, Ltd., 1995); see also the Federation of American Scientists’ Web site last updated August 10, 1999, available at <www.fas.org/man/dod-101/sys/missile/row/hy-1.htm>; see also <www.fas.org/man/dod-101/sys/missile/row/c-201.htm>.

¹⁶ Lin Changsheng, *Modern Weapons and Equipment of the People’s Liberation Army*; Wang Wei [王伟], “Sharp Blade: Development of the PLA-Navy’s AntiShip Missiles” [利刃: 浅析中国反舰导弹], *Naval Weapons* [舰载武器] (May 2008).

¹⁷ From an ASCM conversion standpoint, if one wishes to avoid remaining in the range domain of 100–125 km, one must turn to larger body ASCMs to reach ranges of 350 km to as much as 1,000 km.

¹⁸ Russia, too, has exploited the modularity of its Club [often “Klub”] series of cruise missiles to produce land-attack versions based on the conversion of antiship missiles. See Dennis M. Gormley, “Alternative Ways to Acquire LACMs,” *Dealing with the Threat of Cruise Missiles*, Adelphi Paper 339 (Oxford: Oxford University Press, 2001), 18–28.

¹⁹ Compared with the other conversion challenges, which relate to propulsion and land-attack navigation, this is simple. This information is derived from a DARPA-funded study that one of the authors directed in 1996. His team had access to a government surplus Chinese Silkworm missile and did a full engineering assessment of what it would take to greatly extend the range of the original model.

²⁰ The first Iraqi Silkworm fired against coalition targets came perilously close to hitting a U.S. Marine encampment called Camp Commando in Kuwait on March 20, 2003, the first day of the war. Moreover, the unexpected addition of LACMs to Iraq’s ballistic missile threat contributed to several friendly fire incidents, including Patriot missile units erroneously shooting down two friendly aircraft and killing three crew members, while an F-15 crew destroyed a Patriot radar in the correct belief they were being targeted. Overall, while Patriot missile batteries performed admirably against nine threatening Iraqi ballistic missiles by intercepting all of them, they failed to detect, much less intercept, all five of Iraq’s cruise missiles. For an analysis, see Gormley, *Missile Contagion*, 108–117.

²¹ During the abbreviated life of the Jinin project, Iraqi engineers struggled unsuccessfully to modify a Russian turbine helicopter engine to produce thrust rather than torque. Though this approach was not necessarily an inconceivable path to propulsion success, it posed significant technical challenges that Iraqi engineers only began to appreciate after commencing the conversion effort. See *Comprehensive Report of the Special Advisor to the DCI on Iraq’s WMD*, Vol. II (Washington, DC: Central Intelligence Agency, September 30, 2004), 39–41.

²² As noted above, the Iraqis struggled unsuccessfully to convert a helicopter turbine engine, which produces torque, into an engine that produces thrust needed for a LACM.

²³ “Report of the NATO Parliamentary Assembly, Subcommittee on the Proliferation of Military Technology, Missile Defences and Weapons in Space,” November 2004, available at <<http://natopa.ibicenter.net/default.asp?SHORTCUT=497>>.

²⁴ “2004 Report to Congress of the U.S.-China Economic and Security Review Commission,” June 2004, available at <www.nti.org/db/China/engdocs/USChina_Commission04annual_report.pdf>.

²⁵ The authors are grateful to Gregory DeSantis for information on the Chinese acquisition of this engine and its linkage to the WP-11. It would, of course, seem shortsighted to procure large numbers of HY-4 missiles simply to acquire turbojet engines for an HY-2 conversion program. On the other hand, China may have been willing to sell these engines to Iran.

²⁶ In 2006 Iran was reported to have attempted to acquire new engine components for Silkworm cruise missiles from German and Swiss sources by using cover firms registered in Dubai's free-trade zone. See "Report: Iran Has Conducted Four Missile Tests in 2006," *BBC Worldwide Monitoring*, February 15, 2006.

²⁷ The source for the YJ-63 manufacturer is the *China's Defence Today* Web site. See "KongDi-63 Air-Launched Land-Attack Cruise Missile," October 20, 2008. Another Web source, *softwar.net*, available at <www.softwar.net/c801.html>, claims that the manufacturer is the CPMIEC. However, it would seem more likely that CPMIEC's role in the matter of the YJ-63 LACM is as a potential agent in the missile's export rather than its manufacturer. CPMIEC has been heavily engaged in the export of both nonstrategic ballistic and antiship cruise missiles for decades. Still, besides its export responsibilities, CPMIEC does engage in missile technology production. For more on CPMIEC, see <www.nti.org/facilities/51/>. See also Li Ziyu, "On the Development of China's Air-to-Ship Missiles"; Wang Wei, "Sharp Blade: Development of the PLA-Navy's Anti-Ship Missiles."

²⁸ CEP is an indication of missile accuracy, as defined by the radius of a circle within which half of the missiles are expected to hit.

²⁹ Evan S. Medeiros et al., 94. The deployment date comes from <www.sinodefence.com>.

³⁰ See "KongDi-63 Air-Launched Land-Attack Cruise Missile"; and Douglas Barrie and Robert Wall, "Chinese Cruise Missile Portfolio Expands," *Aviation Week & Space Technology* (September 18, 2005).

³¹ OSD, *China Military Report 2011*, 30. See also National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat* (Wright-Patterson Air Force Base, OH: NASIC, April 2009); and "KongDi-63 Air-Launched Land-Attack Cruise Missile."

³² This is a fairly standard speed for this class of turbojet engine.

³³ Yang Jingqing and Xu Zimao [杨经卿, 徐梓茂], "China's C-601 Air-Ship Missile System" [中国的C-601空舰导弹武器系统], *Missiles & Spacecraft* [世界导弹与航天] (July 1990), 31–34.

³⁴ "KD-63 (YJ-63), K/AKD-63," *Jane's Air-Launched Weapons*, January 28, 2014; "Small Gas-turbine Unit and China's Antiship Cruise Missile" [从小型燃气涡轮发动机看中国巡航导弹的发展], *Shipborne Weapons* [舰载武器], August 2010, 14–25.

³⁵ Beginning in 2012, DOD began referring to the missile as the "CJ-10" in its annual report. OSD, *China Military Report 2012*, 21.

³⁶ Bill Gertz, "Analysts Missed Chinese Buildup," *The Washington Times*, June 9, 2005, A01.

³⁷ NASIC, *Ballistic and Cruise Missile Threat*.

³⁸ The U.S. Government continues to cite a range of 1,500+ km. OSD, *China Military Report 2012*, 21, 42; OSD, *China Military Report 2011*, 2; OSD, *China Military Report 2010*, 31.

³⁹ OSD, *China Military Report 2010*, 66.

⁴⁰ Wendell Minnick, "China Tests New Land-Attack Cruise Missile," *Jane's Missile and Rockets*, October 1, 2004. Minnick cited a "U.S. defense source" as furnishing this information, which certainly sounds speculative.

⁴¹ See "Liu Yongcai: Embracing the Song of the Wind" [刘永才: 胸怀大爱唱大风], *China Space News*, January 26, 2010; and "A Deserving Official Is Rewarded" [有功之臣享受良好待遇], *China Space News*, August 1, 2003. Xue Li now works in the C-919 large aircraft program in Shanghai.

⁴² Xing Yang [邢陽] and Gao Lei [高蕾], "Ma Henghua: Splendid Achievement Bred Through Devotion" [马恒华: 恒心普华章], *China Space News Net* [中国航天新闻网], May 31, 2006.

⁴³ OSD, *China Military Report 2011*, 2.

⁴⁴ See "Photo of the Day: DH-10 LACM on Test Ship 892," *China Defense Blog*, July 29, 2012, available at <<http://china-defense.blogspot.com/2012/07/photo-of-day-dh-10-lacm-on-test-ship-892.html>>.

⁴⁵ OSD, *China Military Report 2011*, 4.

⁴⁶ OSD, "Figure 5. Conventional Anti-Access Capabilities," *China Military Report 2009*, 23.

⁴⁷ “H-6K Badger Strategic Bomber Spotted with 6 x CJ-10 Cruise Missiles,” *Chinese Military Review*, August 2013, available at <<http://chinesemilitaryreview.blogspot.com/2013/08/h-6k-badger-strategic-bomber-spotted.html>>.

⁴⁸ Duncan Lennox, “China’s New Cruise Missile Programme ‘Racing Ahead’,” *Jane’s Defence Weekly*, January 12, 2000.

⁴⁹ See Huang Dong, “China Succeeds in Test-Firing Hongniao Cruise Missile,” *Kuang Chiao Ching* [Wide Angle], no. 384 (September 16–October 16, 2004), 55. See also chapter 2, “China’s Long Distance Land Attack Missiles and its Defense Force” [第二章: 中共遠距攻陸飛彈與其防禦武力] in Lin Tsung-ta [林宗達], *The Military Construction of Missile Offense and Defense in the PRC & USA* [中共與美國飛彈攻防之軍備建構] (Taipei: Crystal Books [晶典文化事業出版社], 2003), 115–120.

⁵⁰ Pakistan reportedly recovered six errant Tomahawk missiles. See Mark Williams, “The Missiles of August—Part II,” *Technology Review*, August 29, 2006, available at <www.technologyreview.com/read_article.aspx?id=17374>. On Pakistan’s acknowledgment of a recovery, see Robert Hewson and Andrew Koch, “Pakistan Tests Cruise Missile,” *Jane’s Defence Weekly*, August 17, 2005, 4.

⁵¹ Of course, the 2000 *Jane’s* report had a different author and appeared in a different *Jane’s* publication than the 2004 report.

⁵² See “A Discussion of the Threat of Land-Attack Cruise Missiles,” *Army Studies Bimonthly* [陸軍月刊], Ministry of National Defense Web site (Taiwan), October 31, 2006; and Huang Dong, 55.

⁵³ The Kh-55SM was introduced in 1986 and was nearly 2 m shorter than the Kh-55 (6.04 vs. 8.09 m) by virtue of using conformal fuel tanks to achieve the same range as the longer Kh-55.

⁵⁴ Russia was not the only state of the former Soviet Union to exploit the inherent modularity of the Kh-55. In 2005, it was disclosed that Ukraine intended to market a shorter-range version called “Korshun,” with a range of 280 km and payload of 480 kg, conveniently making it appear to be MTCR compliant. Ukraine, like Russia, is a member of the MTCR. For technical details on Korshun, see Piotr Butowski, “Ukraine Unveils Its ‘Korshun’ Missile,” *Air & Cosmos*, April 8, 2005.

⁵⁵ The Kh-65SE’s link to the HN-1 can be found at *Global Security*, “Land-Attack Cruise Missiles (LACM), Hong Niao/Chang Feng/Dong Hai-10,” available at <www.globalsecurity.org/wmd/world/china/lacm.htm>.

⁵⁶ For an elaboration of these challenges, see Gormley, *Missile Contagion*, 91.

⁵⁷ Select Committee of the U.S. House of Representatives, “Technical Afterword,” *U.S. National Security and Military/Commercial Concerns with the People’s Republic of China*, Report 105-85 (January 3, 1999), available at <www.gpo.gov/fdsys/pkg/GPO-CRPT-105hrpt851/content-detail.html>.

⁵⁸ “U.S.-China Jet Cooperation,” Northeast Asia Report, *Geostrategy-Direct*, October 7, 2003. For detailed analysis, see Gabe Collins and Andrew Erickson, “Jet Engine Development in China: Indigenous high-performance turbofans are a final step toward fully independent fighter production,” Deep Dive—Special In-Depth Report No. 2, *China SignPost* [洞察中国], no. 39 (June 26, 2011), available at <www.chinasignpost.com/wp-content/uploads/2011/06/China-SignPost_39_-China-Tactical-Aircraft-Jet-Engine-Deep-Dive_20110626.pdf>; Collins and Erickson, “A Chinese ‘Heart’ for Large Civilian and Military Aircraft: Strategic and Commercial Implications of China’s Campaign to Develop High-Bypass Turbofan Jet Engines,” Deep Dive—Special In-Depth Report No. 3, *China SignPost* [洞察中国], no. 47 (September 19, 2011), available at <www.chinasignpost.com/wp-content/uploads/2011/09/China-SignPost_47_Strategic-Commercial-Implications-of-Chinas-Development-of-Hi-Bypass-Turbofans-for-Large-Aircraft_20110919.pdf>.

⁵⁹ “Ukraine Investigates Alleged Illicit Weapons Sales to Iran and China,” *NIS Export Control Observer* 24 (February 2005), 13–15.

⁶⁰ “Taiwan National Charged with Plotting Illegal Export of Engines, Missiles to China,” *International Export Control Observer* 5 (March 2006), 10–11, available at <http://cns.miis.edu/pubs/observer/pdfs/ic-co_0603e.pdf>.

⁶¹ J. Michael Cole, “Chinese agent does ‘disappearing’ act,” *Taipei Times*, August 22, 2011, available at <www.taipetimes.com/News/front/archives/2011/08/22/2003511344>.

⁶² Yihong Zhang, “Beijing Develops New Radar Absorbing Materials,” *Jane’s Defence Weekly*, February 24, 1999, 3.

⁶³ Wu Xincheng, “China Develops New Aviation Material,” *Kanwa Defense Review* (English), December 1, 2006.

⁶⁴ OSD, *China Military Report 2011*, 6.

⁶⁵ *Ibid.*, 30; OSD, *China Military Report 2010*, 31. See also “KongDi-63 Air-Launched Land-Attack Cruise Missile.”

⁶⁶ Chen Wen-cheng [陳文政], “Defense Turning Back” [國防, 向後轉], *New Century Foundation Think Tank Quarterly* [新世紀智庫論壇] 46 (June 30, 2009), 14–17, available at <www.taiwanncf.org.tw/tforum/46/46-04.pdf>. Chen Wen-cheng is former senior advisor for Taiwan’s National Security Council. The YJ-100 designation for the air-launched variant of the DH-10 has also been included in MND briefings.

⁶⁷ Richard Fisher, Jr., “China’s New Strategic Cruise Missiles: From the Land, Sea and Air,” International Assessment and Strategy Center, June 3, 2005, available at <www.strategycenter.net/research/pubID.71/pub_detail.asp>.

⁶⁸ Research Paper 08/15, House of Commons Library, “China’s Military Posture,” available at <www.parliament.uk/commons/lib/research/rp2008/rp08-015.pdf>.

⁶⁹ Ceng Fusheng, “America Considers Communist China’s ‘Counter-Intervention Strategy’” [美因應中共(反介入戰略)的思維], National Policy Foundation National Security Brief, June 17, 2010, available at <www.npf.org.tw/post/3/7677>.

⁷⁰ This section draws on “Table A13: Selected Unmanned Aerial Vehicles (UAV),” from Andrew S. Erickson, “China’s Modernization of Its Naval and Air Power Capabilities,” 121–125; Robert Hewson, “Unmanned Dragons: China’s UAV Aims and Achievements,” *Jane’s International Defence Review*, January 23, 2012. Given the recent profusion of display items and photos from multiple enterprises and universities, it is particularly difficult to determine the actual status and characteristics of specific systems. The data in this section are therefore notional and must be viewed with particular caution.

⁷¹ Jeremy Page, “China’s New Drones Raise Eyebrows,” *The Wall Street Journal*, available at <<http://online.wsj.com/article/SB10001424052748703374304575622350604500556.html>>.

⁷² ONI, *The People’s Liberation Army Navy*, 28–29.

⁷³ Ted Parsons, “PLAN Unveils Communications Relay UAV,” *Jane’s Defence Weekly*, July 13, 2011.

⁷⁴ During the mid- to late-1990s, Israel reportedly collaborated with China on developing a cruise missile similar to Israel’s Delilah, an air-launched turbojet-propelled missile with a range of 400 km or more. One version is equipped with a warhead while another is an anti-radiation drone. During the same period, Israel sold the Harpy UAV, a fire-and-forget weapon capable of attacking and destroying radars to a range of 500 km. A controversy broke out in 2005 between Israel and the United States over Israel’s sale of spare parts for the Harpy to China. On the politics of Israel’s sale of Delilah to China, see Yitzhak Shichor, “Israel’s Military Transfers to China and Taiwan,” *Survival* 40, no. 2 (Spring 1998), 90n39. For technical details on Harpy, see “IAI Harpy and Cutlass,” *Jane’s Unmanned Aerial Vehicles and Targets*, December 12, 2011. On the controversy over spare parts, see Ze’ev Schiff, “US Sanctions Still in Place, Despite Deal over Security Exports,” *Ha’aretz*, August 28, 2005, available at <www.haaretz.com/print-edition/news/u-s-sanctions-still-in-place-despite-dealover-security-exports-1.168365>.

⁷⁵ Yitzhak Shichor, "The U.S. Factor in Israel's Military Relations with China," The Jamestown Foundation, *China Brief* 5, no. 12 (May 24, 2005).

⁷⁶ See, for example, "Stonewalling Defense Official Hints at Gravity of Crisis with U.S. and China," *Israel Insider*, December 29, 2004.

⁷⁷ The authors are indebted to William Murray for his assistance with this paragraph. For the operational context in which Harpys might be employed, see Murray, "Revisiting Taiwan's Defense Strategy," *Naval War College Review* 61, no. 3 (Summer 2008), 13–38.

⁷⁸ "CASC CH-3," *Jane's Unmanned Aerial Vehicles and Targets*, February 23, 2011.

⁷⁹ "CASIC WJ-600," *Jane's Unmanned Aerial Vehicles and Targets*, March 4, 2011.

⁸⁰ "Xian ASN-209," *Jane's Unmanned Aerial Vehicles and Targets*, September 10, 2011.

⁸¹ "Xian ASN-229A," *Jane's Unmanned Aerial Vehicles and Targets*, March 10, 2011.

⁸² Gareth Jennings, "Singapore Airshow 2012: Chinese VTUAV Makes Its Debut," *Jane's Defence Weekly*, February 14, 2012.

⁸³ "GAIC WZ-2000," *Jane's Unmanned Aerial Vehicles and Targets*, September 10, 2011.

⁸⁴ "BUAA Chang Hong," *Jane's Unmanned Aerial Vehicles and Targets*, March 11, 2011.

⁸⁵ "BUAA BZK-005," *Jane's Unmanned Aerial Vehicles and Targets*, January 4, 2012.

⁸⁶ "Xian ASN-206," *Jane's Unmanned Aerial Vehicles and Targets*, March 14, 2011.

⁸⁷ "Xian ASN-207," *Jane's Unmanned Aerial Vehicles and Targets*, December 13, 2011.

⁸⁸ "Xian ASN-104 and ASN-105B," *Jane's Unmanned Aerial Vehicles and Targets*, January 4, 2012.

⁸⁹ "Xian ASN-216," *Jane's Unmanned Aerial Vehicles and Targets*, March 10, 2011.

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⁹¹ "NRIST W-30/W-50 and PW-1/PW-2," *Jane's Unmanned Aerial Vehicles and Targets*, June 1, 2011.

⁹² Bill Gertz, "Inside the Ring: China UAV," *The Washington Times*, October 23, 2008, B01.

⁹³ Ibid.

⁹⁴ Liu Tonglin, Ni Yonghua, and Liu Yin, eds., *Cruise Missiles*, 140–142.

⁹⁵ Even though GLONASS reached the deployment of its full constellation of satellites by 1995, economic conditions in the aftermath of the Soviet Union's collapse reduced the system to only 7 (21 is ideal) operating satellites by 2001. However, Russia's economic fortunes changed dramatically with rising oil revenues, which have put GLONASS back on course. See "About GLONASS," available at <www.insidegnss.com/aboutglonass>.

⁹⁶ For an example of relevant Chinese training, see Lou Yongjun and Wang Jun [楼勇军, 王军], "Shenyang Military Region Air Force Air Regiment Practices Offense and Defense in Complex Electromagnetic Environments" [沈空航空兵集团复杂电磁环境下练功放], *Air Force News* [空军报] (May 26, 2010), 1.

⁹⁷ Huang Jun and Cao Zishen [黄骏, 曹子琛], "Beidou 1 Satellite Navigation System Originally Developed for Military Use" [北斗一号导航卫星并非鸡肋 本为军事运用而生], *Shanghai Oriental Net Oriental Military* [上海东方网东方军事] (November 5, 2008).

⁹⁸ "Beidou/Compass," *Jane's Space Systems and Industry*, November 20, 2012, available at <www.janes.com>; "Real Time Satellite Tracking," ITPROSTAR, available at <www.n2yo.com>; NASA, available at <<http://nssdc.gsfc.nasa.gov/nmc/SpacecraftQuery.jsp>>; "Beidou/Compass," *GPS World*, available at <<http://gpsworld.com/category/gnss-system/beidoucompass/>>.

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¹⁰⁰ "China Starts to Build Own Satellite Navigation System," *Space Daily* (Beijing), November 3, 2006, available at <www.spacedaily.com/reports/China_Starts_To_Build_Own_Satellite_Navigation_System_999.html>.

¹⁰¹ Ibid.

¹⁰² Mure Dickie, "China Launches Navigation Satellite," *Financial Times*, February 4, 2007.

¹⁰³ Andrew S. Erickson, "Satellites Support Growing PLA Maritime Monitoring and Targeting Capabilities," *Jamestown China Brief* 11, no. 3 (February 10, 2011), 13–19.

¹⁰⁴ Liu Jihong and Li Peigong [刘继红, 李沛功], "PLA Employs Beidou and Space Remote Sensing Technology to Raise Precision Strike Capability" [解放军利用北斗及航天遥感技术提升精确打击能], *Liberation Army Daily* [解放军报], May 9, 2010, available at <<http://i.ifeng.com/mil/china/news?aid=3898051>>.

¹⁰⁵ Dong Yingsun [董英隼], "Our Relay Satellite System Tentatively Realizes Land, Sea, Air, Outer Space, and Electron Multi-Dimensional Applications" [我中继卫星系统初步实现陆海空天电多维应用], *China Defence Industry News* [中国军工报], November 3, 2012, 1.

¹⁰⁶ ONI, *The People's Liberation Army Navy*, 28.

¹⁰⁷ Scott Bray, ONI Public Affairs Office, November 2009.

Chapter Four

¹ This section, particularly for order of battle data and numerical estimates, draws in part on Andrew S. Erickson, "China's Modernization of Its Naval and Air Power Capabilities," 60–125.

² Liu Tonglin [刘桐林], *A Sharp Lance of Modern Naval Warfare*, 328.

³ Ronald O'Rourke, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, RL33153 (Washington, DC: Congressional Research Service, August 10, 2012), 21, available at <www.fas.org/sgp/crs/row/RL33153.pdf>.

⁴ Zhang Ju and A Wen [张菊, 阿雯], "The Complete Armaments of the New Century's Frigate" [全副武装的新世纪护卫舰], *Winged Missiles Journal* [飞航导弹], no. 5 (2008), 23.

⁵ Murray, *China's Undersea Warfare*.

⁶ Ibid.

⁷ Zhang Ju and A Wen.

⁸ Scott Bray, ONI Public Affairs Office, November 2009.

⁹ Murray.

¹⁰ OSD, *China Military Report 2011*, 3.

¹¹ Ibid., 4.

¹² "C-602 (HN-1/-2/-3/YJ-62/X-600/DH-10/CJ-10/HN-2000)," *Jane's Strategic Weapons Systems*, June 1, 2010.

¹³ OSD, *China Military Report 2010*, 3; "C-801 (CSS-N-4 'Sardine'/YJ-1/-8/-81) and C-802 (CSSC-8 'Saccade'/YJ-2/-21/-22/-82/-85), C-803 (YJ-3/-83/-88)," *Jane's Strategic Weapons Systems*, June 1, 2010. Quotation from Murray.

¹⁴ See "Carrier Killer vs. Carrier Bodyguard," *Shipborne Weapons* (May 2005), 12–17.

¹⁵ Thomas G. Mahnken, *The Cruise Missile Challenge*, 17.

¹⁶ "Sovremenny class (Project 956E/956EM)," *Jane's Fighting Ships*, August 7, 2009.

¹⁷ "Luda (Type 051DT/051G/051G II) class," *Jane's Fighting Ships*, September 9, 2009.

¹⁸ "Luhai class (Type 051B)," *Jane's Fighting Ships*, September 9, 2009.

¹⁹ "Luzhou class (Type 051C)," *Jane's Fighting Ships*, August 7, 2009.

²⁰ OSD, *China Military Report 2006*, 5.

²¹ "Luhu (Type 052A) class," *Jane's Fighting Ships*, September 9, 2009.

²² For a Chinese analysis of SPY-1 and similar radars, see Liu Zhanrong [刘占荣], "Development of Shipborne Active Phased-Array Radar" [舰载有源相控阵雷达的发展现状], *Command Control & Simulation* [指挥控制与仿真] 2 (February 2005), 82–88.

²³ Scott Bray, "Seapower Questions on the Chinese Submarine Force," position paper, December 20, 2006, available at <www.fas.org/nuke/guide/china/ONI2006.pdf>.

²⁴ O'Rourke.

²⁵ "Jiangwei I (Type 053 H2G) class," *Jane's Fighting Ships*, September 9, 2009.

²⁶ "Jiangwei II (Type 053H3) class," *Jane's Fighting Ships*, September 9, 2009.

²⁷ "Jiangkai I (Type 054) class," *Jane's Fighting Ships*, September 9, 2009.

²⁸ "Jiangkai II (Type 054A) class," *Jane's Fighting Ships*, August 7, 2009.

²⁹ Nan Li, "All at Sea: China's Navy Develops Fast Attack Craft," *Jane's Intelligence Review*, September 2009, 2–3.

³⁰ ONI, *The People's Liberation Army Navy*, 20.

³¹ It would not be possible to use wake-homing torpedoes against *Houbei* catamarans. They do not go fast enough and lack the endurance to catch up with the *Houbei* if it is at speed. It also is unclear if the *Houbei* has sufficient displacement to satisfy whatever arming criteria a wake homer has. In any case, the United States does not have them.

³² Editorial, *Ordnance Knowledge* [兵器知识] (February 2002), 2–3.

³³ On swarming tactics, see John Arquilla and David Ronfeldt, *Swarming and the Future of Conflict* (Santa Monica, CA: RAND, 2000), available at <www.rand.org/pubs/documented_briefings/DB311>.

³⁴ OSD, *China Military Report 2012*, 31.

³⁵ Eric Wertheim, "Finding the Right Mix—China," *U.S. Naval Institute Proceedings* 132, no. 3 (March 2006), 56–58.

³⁶ OSD, *China Military Report 2013*, 14–15.

³⁷ OSD, *China Military Report 2011*, 4.

³⁸ Chi Gang and Wang Shuzong [迟刚, 王树宗], Naval University of Engineering, Wuhan [海军工程大学 武汉], "Research of the Operational Effectiveness of Submarine-Launched Cruise Missiles" [潜射巡航导弹作战效能研究], *Aerospace Control* [航天控制] 22, no. 2 (April 2004), 42–45.

³⁹ See "The Klub Family/Klub S Klub N/(91RE2; 91RE1; SS-N-27B (3M54TE; 3M54E); SS-N-30B (3M14TE; 3M14E))/Klub K," *Jane's Naval Weapons Systems*, October 10, 2012; and Carlo Kopp, "Precision Guided Munitions in the Region," *Air Power Australia*, August 2009, available at <www.ausairpower.net/APA-Regional-PGM.html>. Direct quotation from Murray.

⁴⁰ "Kilo class (Project 877EKM/636)," *Jane's Fighting Ships*, September 9, 2009.

⁴¹ OSD, *China Military Report 2011*, 4.

⁴² Ibid.

⁴³ OSD, *China Military Report 2010*, 29.

⁴⁴ Murray.

⁴⁵ O'Rourke, 8, 10. This figure could increase as information emerges concerning dates of commissioning for the 093 SSN and 094 SSBN.

⁴⁶ Jim Yardley and Thom Shanker, "Chinese Navy Buildup Gives Pentagon New Worries," *The New York Times*, April 8, 2005.

⁴⁷ OSD, *China Military Report 2012*, 31.

⁴⁸ "Type 039 (Song class)," *Jane's Underwater Warfare Systems*, November 11, 2009.

⁴⁹ "Yuan class (Type 041)," *Jane's Fighting Ships*, February 12, 2013.

⁵⁰ "Yuan class (Type 041)," *Jane's Fighting Ships*, September 9, 2009.

⁵¹ "Shang class (Type 093)"; ibid.

⁵² Wu Kai [吴锴], "An Interview with Huang Xuhua: SSN Design Philosophy" [攻击型核潜艇的计划思想—再访黄旭华院士], *Ordnance Knowledge* [兵器知识] (June 2000), 23.

⁵³ See, for example, Tian Jinwen [田金文], "How to Improve Cruise Missile Survivability and Attack Effectiveness" [如何提高巡航导弹生存能力和打击效果], *Aerospace Electronic Warfare* [航天电子对抗], no. 1 (2005), 12–14; Cao Xiaopan [曹晓盼], "The Current Status of China's Cruise Missiles" [中国的巡航导弹现状], *Shipborne Weapons* [舰载武器] (November 2004), 26–27.

⁵⁴ Zhao Zhengye [赵正业], *Principles of Submarine Fire Control* [潜艇火控原理] (Beijing: National Defense Industry Press [国防工业出版社], September 2003), 332.

⁵⁵ *Ibid.*, 331–333.

⁵⁶ *Ibid.*, 329.

⁵⁷ This is very difficult to determine from a diesel submarine at anything other than very short ranges.

⁵⁸ Range is difficult to determine and requires multiple observations to plot a track. Sonar is not equivalent to radar in this regard.

⁵⁹ This might involve antisubmarine rockets (ASROC) in the case of the United States, LAMPS helicopters with torpedoes, or P-3 ASW aircraft.

⁶⁰ Accurately launching a cruise missile from underwater is not easy, according to a researcher at Zhengzhou Mechanical and Electrical Engineering Research Institute. See Ma Zhenyu [马震宇], "The Delivery Equipment for U.S. and French Submarine-Launched Cruise Missiles and Its Development" [美法潜射飞航导弹运载体及其发展], *Winged Missiles Journal* [飞航导弹], no. 5 (2008), 9–12.

⁶¹ This Chinese analysis may seem peculiar to U.S. operators. Over-the-Horizon Radar inadequacy may imply using other sensors; it is not clear how it implies the need for relay stations, which the Chinese author suggests are for a previously unmentioned distributed sensor network.

⁶² Chen Qi, Ma Wei, and Jiang Ning [陈奇, 马威, 姜宁], "Electromagnetic Compatibility Model for Using Decoy Jamming with Close-in Auxiliary Artillery System" [箔条干扰与副炮系统战斗使用电磁兼容模型], *Fire Control and Command Control* [火力与指挥控制] (October 2007), 112–115.

⁶³ For Chinese research on decoys and jamming by experts at China North Optical-electrical Technology Co. and Harbin Institute of Technology's School of Mecha-tronics Engineering, see Wang Qi, Wan Zhongnan, and Han Junwei [王琪, 万中南, 韩俊伟], "Research on Interference in the Infrared and Radar Guidance of Air-to-Air Missiles" [具有防御性的空空导弹干扰], *Fire Control and Command Control* [火力与指挥控制] (July 2008), 21–23.

⁶⁴ Zhao Zhengye, 320.

⁶⁵ OSD, *China Military Report 2011*, 4, 76. Another set of estimates including helicopters produces 2,516–2,596 PLAAF aircraft and 179–245+ PLAN aircraft for a total of 2,695–2,841+ aircraft. One of the authors derived this figure by adding helicopter airframe range estimates of 20–100 (PLAAF) and 34–100 (PLAN), the respective estimates from "Air Force, China," *Jane's World Air Forces*, June 10, 2012, and O'Rourke. For the respective helicopter estimates, see "Air Force, China," (for PLAAF low estimate); Dennis J. Blasko, "Chinese Helicopter Development: Missions, Roles, and Maritime Implications," in *Chinese Aerospace Power: Evolving Maritime Roles*, ed. Andrew S. Erickson and Lyle J. Goldstein, 154 (Annapolis: Naval Institute Press, 2011) for PLAAF high estimate; O'Rourke, 38, for PLAN low estimate; Blasko, 154.

⁶⁶ Sun Dayong and Li Hui [孙大勇, 李慧], "On Building Space Military Force" [关于空间军事力量建设], *National Defense Science and Technology* [国防科技] 29, no. 6 (2008), 37–40.

⁶⁷ John Wilson Lewis and Xue Litai, "China's Search for a Modern Air Force," *International Security* 24, no. 1 (Summer 1999), 64–94; Erik Lin-Greenberg, "Offensive Airpower with Chinese Characteristics: Development, Capabilities, and Intentions," *Air & Space Power Journal* (Fall 2007), 67–77.

⁶⁸ David Shlapak, "Equipping the PLAAF: The Long March to Modernity," *The Chinese Air Force: Evolving Concepts, Roles, and Capabilities*, ed. Richard P. Hallion, Roger Cliff, and Phillip C. Saunders, 191–212 (Washington, DC: NDU Press, 2012).

⁶⁹ "Air Force—China," *Jane's Sentinel Security Assessment—China and Northeast Asia*, January 5, 2007.

⁷⁰ Murray.

⁷¹ These are projected to be supplemented by 8 Ilyushin Il-78M four-engined tankers reportedly ordered in September 2005, the deployment of which "will extend the range and strike potential of China's bomber and fighter aircraft." OSD, *China Military Report 2007*, 6.

⁷² Ibid., 6.

⁷³ "Sukhoi Su-27," *Jane's All the World's Aircraft*, December 31, 2009.

⁷⁴ "Sukhoi Su-30 MK 2 Flanker," *Jane's Fighting Ships*, January 20, 2009.

⁷⁵ "Air Force—China," *Jane's Sentinel Security Assessment*.

⁷⁶ "Fighter Aircraft," *China Defence Today*, available at <www.sinodefence.com/airforce/fighter/default.asp>.

⁷⁷ For details on the J-10, see Phillip C. Saunders and Joshua K. Wiseman, *Buy, Build, or Steal: China's Quest for Advanced Military Aviation Technologies*, China Strategic Perspectives 4 (Washington, DC: NDU Press, 2011), 4, available at <www.ndu.edu/press/lib/pdf/china-perspectives/ChinaPerspectives-4.pdf>.

⁷⁸ "Air Force—China," *Jane's Sentinel Security Assessment*.

⁷⁹ Several versions including the two-seat J-10S and its strike and air defense suppression variant J-10B are reportedly undergoing testing. David Saw, "The Chinese Air Force Growth Path," *Asian Defence & Diplomacy* 15 (December 2008), 21.

⁸⁰ "Air Force—China," *Jane's Sentinel Security Assessment*.

⁸¹ "CAC J-10," *Jane's All the World's Aircraft*, November 12, 2009.

⁸² OSD, *China Military Report 2010*, 48.

⁸³ OSD, *China Military Report 2009*, 50.

⁸⁴ Dong Wenxian [董文先], *On Modern Air Force (Supplement)* [现代空军论(续篇)] (Beijing: Blue Sky Press [蓝天出版社], 2005), 60–67.

⁸⁵ See, for example, Wendell Minnick, "China Tests New Land-Attack Cruise Missile," *Jane's Missiles and Rockets*, September 21, 2004.

⁸⁶ LACMs can carry submunitions (see French Apache, German KEPD, and others). Submunitions would be best used to close down airfield runways, but ballistic missiles can do the same although they likely do not possess the accuracy of LACMs.

⁸⁷ "XAC H-6," *Jane's All the World's Aircraft*, March 10, 2009.

⁸⁸ Thomas G. Mahnken, *The Cruise Missile Challenge*, 17; Li Ziyu, "On the Development of China's Air-to-Ship Missiles."

⁸⁹ According to *Jane's*, the "First H-6H flown on 2 December 1998 and made the first successful air launch of a YJ-63 in November 2002." See "XAC H-6," *Jane's All the World's Aircraft*, March 10, 2009.

⁹⁰ Wang Jin and Fu Qi [王瑾, 傅琦], "Pride and Prejudice: An Interpretation of Keating's Visit to China" [傲慢与偏见: 解读基廷访华], *Ordnance Knowledge* [兵器知识] (March 2008), 38–40.

⁹¹ OSD, *China Military Report 2009*, 50.

⁹² Evan S. Medeiros et al., 199.

⁹³ "China," *Jane's World Navies*, March 26, 2012.

⁹⁴ See "Su-30MKK Multirole Fighter Aircraft," February 20, 2009, available at <www.sinodefence.com/airforce/fighter/su30.asp>.

⁹⁵ Vladimir Karnozov, "New Su-30MK3 Flight Tested," *Flight Global*, June 1, 2004, available at <www.flightglobal.com/news/articles/new-su-30mk3-flight-tested-182372/>.

⁹⁶ "Procurement—China," *Jane's Sentinel Security Assessment—China and Northeast Asia*, December 13, 2006.

⁹⁷ "Air Force—China," *Jane's Sentinel Security Assessment*.

⁹⁸ Integrating operations between a highly regimented and rigidly structured PLAAF and an immature and sea-based PLAN contingent would require technological and service-culture innovations, as well as exercises less carefully scripted than has been usual, to develop the requisite interoperability and interservice coordination and avoid “seams” or “conflicts” developing from overlapping capabilities and areas of responsibility.

⁹⁹ Blasko, 154.

¹⁰⁰ “C-701 (YJ-7, Kosar),” *Jane’s Air-Launched Weapons*, June 9, 2009.

¹⁰¹ “HAI (Eurocopter) Z-9 Haitun,” *Jane’s All the World’s Aircraft*, January 2, 2013; *ibid*.

¹⁰² The Ka-28’s VGS-3 submarine-detecting dipping sonar and sonar buoys, and any further improvements in rotary wing aviation, will help the PLAN to address one aspect of its significant weakness in antisubmarine warfare.

¹⁰³ “WZ-10 Attack Helicopter,” *China Defence Today*, available at <www.sinodefence.com/airforce/helicopter/wz10.asp>.

¹⁰⁴ ONI, *A Modern Navy with Chinese Characteristics*, 18.

¹⁰⁵ Bray, ONI Public Affairs Office, November 2009.

¹⁰⁶ Wang Jinchuan and Wei Jingbiao [王金川, 魏靖彪], “A Study on the Aerodynamic Interference of the Rotor-Fuselage Combination on Airborne Missiles” [旋翼-机身组合体对机载导弹的气动干扰], *Fire Control & Command Control* [火力与指挥控制] (May 2008), 93–96.

¹⁰⁷ OSD, *China Military Report 2011*, 2.

¹⁰⁸ Wang Houqing and Zhang Xingye, eds. [王厚卿, 张兴业], *The Science of Campaigns* [战役学] (Beijing: National Defense University Press [国防大学出版社], 2000), 340.

¹⁰⁹ The “Naval Base Defense Campaign” is described in detail in *Science of Campaigns* [战役学] as part of a larger “Sea Transportation Defense Campaign.” A “long-range firepower region” consists of land-to-ship missile firepower. Zhang Yuliang, Yu Shusheng, and Zhou Xiaopeng, eds. [张玉良, 主编; 郁树胜, 周晓鹏, 副主编], *Science of Campaigns* [战役学] (Beijing: National Defense University Press, 2006), 306.

Chapter Five

¹ Roger Cliff et al., *Entering the Dragon’s Lair: Chinese Antiaccess Strategies and Their Implications for the United States* (Santa Monica, CA: RAND, 2007), 28–29. Also of value on Chinese military doctrine is *China’s Revolution in Doctrinal Affairs: Emerging Trends in the Operational Art of the Chinese People’s Liberation Army*, ed. James Mulvenon and David M. Finkelstein (Alexandria, VA: CNA Corporation, 2005). Logically, the point of A2/AD is to keep out U.S. forces by military means (including deterrence). If the entire war is supposed to be concluded before U.S. forces arrive, then the “deterrent” is political, and all those A2/AD forces would be irrelevant. That “waiting” aspect is part of China’s military, and therefore procurement, plan.

² DOD, *Quadrennial Defense Review Report*, February 6, 2006 (Washington, DC: Government Printing Office, 2006), 29.

³ Liu Tonglin [刘桐林], *A Sharp Lance of Modern Naval Warfare*, 321.

⁴ Yi Heng and Xin Hua [宣恒, 新华], “Six Trump Cards to Cope with Aircraft Carriers” [航母煞星: 对付航母的六大撒手锏], *World Outlook* [国际展望], no. 3 (February 2001), 60–61; Wang Jianfei, Wu Wenjun, Peng Xiaolong, and Xiong Ping [王剑飞, 武文军, 彭小龙, 熊平], “Analysis on Effectiveness of Air-Attack Firepower of a U.S. Carrier Fighting Group” [美军航母战斗群空袭火力及其效能分析], *Intelligence, Command, Control and Simulation Technology* [情报指挥控制系统与仿真技术] 27, no. 1 (February 2005), 24–30; He Wentao and Wu Jiawu [何文涛, 吴加武], “A Study of Countering Aircraft Carrier Battle Groups” [航母编队特点及对策研究], *Modern Defense Technology* [现代防御技术] 32, no. 5 (October 2004), 18–20, 29; Ma Shiqiang

[马世强], "How to Engage the Aircraft Carrier?" [攻击航母—反舰导弹命中目标前后], *Shipborne Weapons* [舰载武器] (December 2007), 104–109.

⁵ Nevertheless, Taiwan's ability to defend against at least some cruise missiles should not be ruled out. Russia's SA-20 is advertised as being able to shoot down cruise missiles. The Patriot, also state of the art, can also shoot down cruise missiles, but how well and how many? Recent U.S. arms sales to Taiwan include SM-2s, fired from *Kidd*-class destroyers, which are designed to shoot down low-flying cruise missiles. But SM-2s can also intercept higher-flying LACMs.

⁶ According to *Jane's*, "There has always been the belief that the S-300 system has a capability against ASM and SSM and reports indicate that trials in the Far East against simulated ship-launched cruise missiles were successfully completed in 1991." China has both acquired the SA-20 and built it under license. "S-300/Favorit (SA-10 'Grumble'/SA-20 'Gargoyle')," *Jane's Strategic Weapon Systems*, January 27, 2009.

⁷ SM-6s coupled with airborne platform tracking data from the U.S. E-2D are needed to deal with cruise missiles. "Patriot PAC-3," *Jane's Land-Based Air Defence*, May 21, 2009.

⁸ Zhang Weiping, Nanjing Military Region Headquarters [张维平], "Introduction to Importance and Role of Joint Anti-Blockade Operations" [浅谈联合反封锁作战的地位作用], *Military Art Journal* [军事学术] (December 2003), 16–18.

⁹ The authors thank Dennis Blasko for this point.

¹⁰ *Science of Campaigns* (2006).

¹¹ This point was emphasized by a Chinese interlocutor in Beijing, 2008.

¹² "Air Defense Campaigns," in *Science of Campaigns* (2006), 602–615.

¹³ He Wentao and Wu Jiawu [何文涛, 吴加武], "A Study on Countering Aircraft Carrier Battle Groups" [航母编队特点及对策研究], *Modern Defence Technology* [现代防御技术] 32, no. 5 (October 2004), 18–29.

¹⁴ *Ibid.*, 29.

¹⁵ Wu Qiang and Jiang Yuxian [吴强, 姜玉宪], "Research on Integrated Penetration of the Anti-Ship Missile" [反舰导弹综合突防技术], *Journal of Beijing University of Aeronautics and Astronautics* [北京航空航天大学学报] 30, no. 12 (December 2004), 1212–1215.

¹⁶ Yan Zhongxi, Wang Gang, and Yang Zu-kui [颜仲新, 王刚, 杨祖快], "An Analysis of the Antiship Missiles Saturation Attack Capability of an 'Arleigh Burke'-Class Destroyer" ["伯克"级驱逐舰抗反舰导弹饱和和攻击能力分析], *Modern Defence Technology* [现代防御技术] 30, no. 3 (June 2002), 10–13.

¹⁷ Radar could conceivably detect electromagnetic radiation associated with the launch. Wang Tao and Kuang Zhikao [王涛, 旷志高], "The Stealth Technology of Anti-ship Missiles" [反舰导弹的隐身技术], *Modern Ships* (April 2005), 38.

¹⁸ Kan Yabin and Xue Jianfei [阚亚斌, 薛剑飞], "Command and Tactical Decision-making for the Over-the-Horizon Leap of Anti-Ship Missile Attack" [反舰导弹攻击指挥与战术—决策的超视距跨越], *Winged Missiles Journal* [飞航导弹], no. 5 (2004), 12–16, 44.

¹⁹ Tian Ying and Guo Chan [天鹰, 郭婵], "Technical Advances in Shipborne Antimissile Equipment of the Chinese Navy" [中国海军舰艇反导装备的技术进步], *Shipborne Weapons* [舰载武器] (June 2008), 26–32.

²⁰ Cai Xiao, Guo Wei, and Zhou Yingfang [蔡啸, 郭伟, 周应芳], "Reconnaissance & Jamming to American Military Tactical Digital Information Link (TADIL) A" [对美军战术数字信息链路(TADIL)A的侦察与干扰], *Ship Electronic Engineering* [舰船电子工程] 25, no. 4 (April 2005), 116–123.

²¹ PLAN research has also focused on other aspects of the "actual war" including information operations and antisubmarine warfare (ASW). Sun Honggang, Chen Yinjie, and Huai Wanjiang [孙宏纲, 陈印杰, 槐万景], "Analysis of Capabilities on the Antisubmarine Equipment U.S. Navy's Aegis Warships" [美海军"宙斯盾"级舰艇反潜装备性能分析], *Modern Defence Technology* [现代防御技术] 33, no. 5 (October 2005), 11–15.

²² See “Carrier Killer vs. Carrier Bodyguard,” *Shipborne Weapons* (May 2005), 12–17.

²³ See, for example, Wang Yi, Fu Yufeng, and Fang Lihua [王毅, 付宇峰, 方立华], “Missile Battle under Electromagnetic Conditions—A Witness Account of a Destroyer Flotilla in Conducting Anti-Missile Drills with Modern Warships” [电磁网里的导弹格斗—目击某驱逐舰支队新型舰艇抗导演练], *People’s Navy* [人民海军报], February 16, 2009, 2; Jiang Shuyi and Lu Jun [姜书逸, 卢军], “A Sky Full of Sharp Swords: A Sky Wolf is Launched—Sidelights on the Qingdao Garrison’s Execution of the ‘Militia Military Training and Evaluation Outline’ Live Troop Exercise” [长空利剑射天狼—青岛警备区落实“民兵军事训练与考核大纲”实兵演练侧记], *Liberation Army Daily* [解放军报], July 15, 2007, 2, available at <www.chinamil.com.cn/>; Liu Zhiyong, Hu Ren, and Yan Guoyou [刘志勇, 胡韧, 闫国有], “Putting the New Training Outline into Effect in the Training Ground (Part 2)—Two Missiles Fired Immediately One After Another Hit Their Targets With Precision” [新“大纲”落实在训练场(2)—双弹连发精确命中], *Air Force News* [空军报], January 11, 2010, 2.

²⁴ For an exercise involving mobilization of truck-mounted cruise missiles by a North Sea Fleet shore-based missile regiment, see Zhang Tengfei and Wang Songqi [张腾飞, 王松岐], “Never Missing a Target in Faraway Regions” [千里之外弹无虚发], *People’s Navy*, December 8, 2009.

²⁵ For the PLAN, see Chen Ji and Zhou Yongjun [陈吉, 周拥军], “100% Hit Rate in First Live Launch of New Type of Missile—Advanced Training and Joint Attack” [首次实射新型导弹命中率100%—超前训练合力攻关], *People’s Navy*, September 17, 2007, 1.

²⁶ Zhang Tiehan, Yu Wenwu, and He Tianjin [张铁汉, 余文武, 何进天], “Debut of Cruising Sharp Sword Startles the World—Documentary of the 28th Armament Square Team Participating in Military Parade in the Capital City for the 60th Anniversary of the Founding of New China” [横空出世, 巡航利剑惊寰宇—参加新中国成立60周年首都阅兵装备第28方队纪实], *Rocket Force News* [火箭兵报], October 2, 2009, 8.

²⁷ Yu Wenwu, Yu Juncheng, and Chen Shoufu [余文武, 余俊成, 陈寿富], “New Assassin’s Mace: A Big Drama at the Beginning of the Year Directly Leads to the Battlefield—Witnessing a Launch Exercise of a Certain Cruise Missile Brigade Under the Second Artillery Corps” [新型“撒手锏”: 开年“大戏”直通战场—第二炮兵某巡航导弹旅发射演练目击记], *China Youth Daily* [中国青年报], January 15, 2010, available at <http://zqb.cyol.com/content/2010-01/15/content_3040811.htm>.

²⁸ Xiong Yongxin [熊永新], “Recently, Reporters Followed a New-Type Shore-to-Ship Missile Launch Vehicle from a Certain South Sea Fleet Coastal Missile Regiment Execute a Maritime Counter-Blockade Exercise, Ears Listening—Thunderclaps Echo in Littoral Forests” [日前, 记者跟随南海舰队某岸导团新型岸舰导弹发射车, 进行一场海上反封锁作战演习, 亲耳谛听—海岸丛林响霹雳], *Liberation Army Daily* [解放军报], September 28, 2009, 8.

²⁹ Zhang Qi, Liu Xu, and Cao Guoqiang [张旗, 刘许, 曹国强], “A ‘Missile Offensive and Defensive War’ Starts on the Network—Observations of a Network Confrontational Exercise in the Combat Command Laboratory at the Second Artillery Corps’ Command College” [‘导弹攻防战’在网上展开—第二炮兵指挥学院作战指挥实验室网络对抗演习目击记], available at <www.chinamil.com.cn/site1/zbxl/2009-07/13/content_1833784.htm>; Li Tilin [李体林], “The Experts Know the Way: The Network Is the New Path for Generating Fighting Capacity” [内行看门道: 网络, 战斗力生成的新途径], *Liberation Army Daily* [解放军报], July 13, 2009, 8.

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³¹ Mi Jinguo and Yuan Yonghua, “In the Teeth of the Storm, the Dragon and Tiger Do Battle—Personally Experiencing the Confrontation Training of Ship 112 and a Certain New Model Destroyer,” *People’s Navy*, January 30, 2008, 1.

³² Wu Hong [吴弘], "Checking on Elite Troops Using Iron Law Drill Manuals—Tracking the Activities of a Certain Speedboat Flotilla in 'Concentrating on Carrying Out Training Based on the New Outline'" [铁律操典点精兵—追踪某快艇支队'按新大纲正规模训集中抓'活动], *People's Navy*, February 8, 2010, 1; Gai Xiaoning and Huang Binbin [盖晓宁, 黄彬彬], "The Ocean of Fog Choked the Enemy's Throat—A Witness Account of a Missile Attack Drill of a North Sea Fleet Guided Missile Frigate Group under Complex Conditions" [雾海锁敌喉—目击北海舰队某导弹护卫大队复杂条件下导弹攻击演练], *People's Navy*, September 23, 2009, 3.

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³⁴ Cao Haihua, "Frigate group in live missile launching drill," *China Military Online*, September 2006, available at <http://english.chinamil.com.cn/site2/militarydatabase/2006-09/26/content_599958.htm>.

³⁵ Yuan Yongdong, "Anti-Air Attack Training on the Sea," *China Military Online*, January 2006, available at <http://web.archive.org/web/20060721012138/http://english.chinamil.com.cn/site2/militarydatabase/2006-01/18/content_390095.htm>.

³⁶ Liu Jiafeng and Yin Fei, "Aviation Division Hones First-Rate Fighting Capability over Blue-Sea Waters," *China Military Online*, January 2006, available at <http://web.archive.org/web/20060720151230/http://english.chinamil.com.cn/site2/militarydatabase/2006-01/17/content_386786.htm>.

³⁷ Liu Hong and Li Gaojian [刘洪, 李高健], "Flying Boats Annihilate 'Stubborn Enemies'—Eyewitness to Live Missile Attack Exercise by New Type of Guided Missile Fast Boat" [飞舟歼'顽敌'—亲历某支队新型导弹快艇实弹攻击演练], *People's Navy*, July 29, 2009, 3. This appears to represent a significant improvement over the Type 022's apparent debut live-fire training in "rough seas" in the South Sea Fleet, when it had to retreat from sea areas when wind and waves intensified. Zhang Guanghui, "A Maritime Garrison District Extensively Attacks a Target on Distant Seas—A New Type of Missile Boat Launches an Actual Missile for the First Time, Quickly Hitting Its Target," *People's Navy*, December 14, 2007, 1. For another apparent Type 022 missile attack exercise, see Liao Haifeng and Fang Lihua, "Missiles Break Through 'Electronic Blockade'—An Eyewitness Account of a Speedboat Flotilla of the East Sea Fleet in Conducting Missile Attack Training under Complex Electromagnetic Conditions," *People's Navy*, November 12, 2008, 2.

³⁸ Gao Yi [高毅], "Raise Capability for Breaking Through Anti-Submarine Blockade—A Certain South Sea Fleet Submarine Flotilla Focuses on Characteristics of New Armament to Develop New Methods of Operations" [南海舰队某潜艇支队探索新型潜艇实射经验—首次实射导弹—击命中], *People's Navy*, September 21, 2009, 2; Gao Yi and Peng Jiu, "The First Live Missile Launch from a Modern Submarine Scored a Perfect Hit—The Experience of a Submarine Flotilla of the South Sea Fleet in a Live Missile Launch from a Modern Submarine," *People's Navy*, November 9, 2007, 1.

³⁹ ONI, *The People's Liberation Army Navy*.

⁴⁰ Sun Qinfu and Zhang Shoujun, "A Single Submarine Acting Alone Successively Annihilated Four Vessels—An Extremely Difficult Task Comparable to Pulling Teeth from a Tiger's Mouth; A North Sea Fleet Submarine Flotilla Achieves Breakthroughs in Launching Attacks Against Surface Vessels in Complex Hydroacoustic Environments," *People's Navy*, April 8, 2008, 2.

⁴¹ ONI, *The People's Liberation Army Navy*.

⁴² Zhang Luocan and Zhang Shengjiang [张罗灿, 张圣江], "Electromagnetic Waves Coming from the Depths of the Ocean—On the Scene of a Coordinated Drill between a Surface Ship and Submarine 312 of a South Sea Fleet Submarine Flotilla," [来自大洋深处电波—连线某潜艇支队312艇潜舰协同演练现场], *People's Navy*, October 16, 2009, 1.

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⁴⁷ Li Tang and Wang Shijun [李唐,王世均], “Far Sea Assault, A Group of Nighthawks Flying Above Waves—On the Scene at South Sea Fleet Aviation Bomber Regiment’s Night Tactics Test” [远洋突击—一群夜鹰贴浪飞—南航某轰炸机团夜间战术考核现场见闻], *People’s Navy*, November 24, 2008, 2.

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⁴⁹ Bian Chungang and Xu Hongchun [卞春光, 余红春], “Busy Final Training” [岁末训练忙], *Air Force News*, November 13, 2009, 2; Huang Yanzhuang [黄演庄], “Nighttime Confrontation” [夜间对抗], *Air Force News*, November 23, 2009, 3.

⁵⁰ Liao Qirong and Li Rui [廖启荣, 李瑞], “Achieving Breakthroughs in Nighttime Operations Through Nighttime Training—A Nanjing Military Region Air Force Aviation Division Successfully Launches Precision Strikes Using a New Type of Weapon” [夜间突破夜间练—南空航空兵某师成功实施某新武器精确打击], *Air Force News*, December 4, 2008, 2.

⁵¹ Bian Chunguang and Zhao Lingyu [卞春光, 赵凌宇], “Guangzhou Military Region Air Force Aviation Regiment Organizes Sea Training by Real-war Standards” [广空航空兵某团以实战标准组织海训纪实], *Air Force News*, April 29, 2008, 2.

⁵² The original “Three Attacks and Three Defenses” was a concept from the 1960s. See Han Tingjin and Qi Zeqing [韩挺进, 齐泽强], eds., *The Air Defense Forces’ New “Three Attacks and Three Defenses”* [防空兵新“三打三防”] (Beijing: Liberation Army Press, 2001).

⁵³ See Kenneth W. Allen, “The Organizational Structure of the PLAAF,” in *The Chinese Air Force: Evolving Concepts, Roles, and Capabilities*, ed. Richard P. Hallion and Roger Cliff, 95–132 (Washington, DC: National Defense University Press, 2012).

⁵⁴ OSD, *China Military Report 2012*, 24.

⁵⁵ OSD, *China Military Report 2011*, 32.

⁵⁶ Combat identification proved more than nettlesome for the United States during the 2003 war against Iraq when Patriot missile defense batteries were involved in a series of friendly-fire incidents, leading to the loss of two friendly aircraft and three crewmembers, while a U.S. F-15 crew destroyed a Patriot radar that had “painted” and thereby threatened the aircraft. For a full account, see Gormley, *Missile Contagion*, 107–122.

⁵⁷ For example, whereas today’s airborne radars can detect out to distances of several hundred km, ground-based radars on land and at sea might first see a low-flying cruise missile when it has closed to some 35 km or less.

⁵⁸ The larger the antenna array’s size, the greater the detection distance.

⁵⁹ Liu Tonglin, Ni Yonghua, and Liu Yin, eds., *Cruise Missiles*, 197–201.

⁶⁰ “The U.S. Military’s Strategic Perspective on the Asia-Pacific: Land, Water, and Air Surround a Potential Enemy” [美军亚太战略透视: 水陆空包围潜在对手], July 20, 2008, available at <<http://mag.chinareviewnews.com/doc/1006/9/9/6/100699662.html?coluid=7&kindid=0&docid=100699662>>.

⁶¹ Lu Ping and Hu Xiaoping [陆平, 湖小平], “Preliminary Analysis of the Characteristics of a Joint Counter-Blockade Operation” [联合反封锁作战浅析], *Military Art Journal* [军事学术] (December 2003), 22–24.

⁶² Ting Jianliang [程建良], “Our Country’s ‘Coastal City Circles’ Air Defense” [我国‘沿海都市圈’的防空布势], *Naval and Merchant Ships* [舰船知识] 341, no. 2 (February 2008), 33–35.

⁶³ Zhang Xiaoqian, Yi Jiansheng, and Cai Junfeng [张晓倩, 易建政, 蔡军锋], “National Defense Cave Depot Protection Techniques Against Cruise Missile Attack” [基于巡航导弹攻击的国防洞库防护技术], *Chinese Journal of Underground Space and Engineering* [地下空间与工程学报] 4, no. 1 (February 2008), 16–17. This may be a veiled reference to China’s first generation nuclear ICBMs, some of which were stored in caves. Of course, protecting cave depots is something that not only mainland China, but also Taiwan, must be concerned about.

⁶⁴ Dominic DeSciscio, “Red Aegis,” *U.S. Naval Institute Proceedings* 130, no. 7 (July 2004), 56–58.

⁶⁵ Li Juwei, Jiang Wenzhi, and Teng Kenan [李居伟, 姜文志, 滕克难], “Study of Low-Altitude Anti-Missile Damage Zone of Network Centric Ship to Air Missile” [网络化舰空导弹低空反导杀伤区研究], *Modern Defense Technology* [现代防御技术] 36, no. 4 (August 2008), 17–18.

⁶⁶ OSD, *China Military Report 2011*, 32.

⁶⁷ Zhang Yuliang et al., eds., “Chapter 14: Anti Air Raid Campaign,” *Science of Campaigns*, 331–351.

⁶⁸ Zhao Jiandong and Zhao Yingjun [赵建东, 赵英俊], “The Key to 21st Century Air Defense—Anti-Missile Technology” [21st世纪防空的关键—反导], *Winged Missiles Journal* [飞航导弹] (June 2007), 14.

⁶⁹ See Zhao Jichen [赵继臣], “On the Basic Characteristics of Integrated Joint Firepower Strikes” [论一体化联合活力打击的基本特征], *Military Art Journal* [军事学术] (July 2004), 51–52.

⁷⁰ He Wentao and Wu Jiawu [何文涛, 吴加武], “A Study of Countering Aircraft Carrier Battle Groups” [航母编队特点及对策研究], *Modern Defence Technology* [现代防御技术] 32, no. 3 (June 2004), 18–20.

⁷¹ Su Xiancheng, Yu Xiaohong, Wang Jia, and Gao Fei [苏宪成, 于小红, 王佳, 高飞], “An Analysis of Aerial Electronic Jamming of Cruise Missiles” [对巡航导弹的空间电子干扰途径分析], *Winged Missiles Journal* [飞航导弹], no. 6 (2008), 35–37, 64; Tang Shoulun and Jiang Boyou [唐守伦, 江伯友], “The Missiles Whistled Down—On the Spot Report of Nanjing Military Region Air Defense Brigade Focuses on Promoting Real Transformation in Training” [导弹呼啸靶机落—南京军区某防空旅着眼实战推进训练转变纪实], *Liberation Army Daily* [解放军报], October 21, 2007, 7.

⁷² Yang Yi, Liu Ren, and Hu Lin [杨艺, 刘仁, 胡林], “Analysis on the Effectiveness of Terminal Aerial Defense Missiles Against Cruise Missiles” [末端防空武器系统对巡航导弹的作战效能分析], *Modern Defense Technology* [现代防御技术] 36, no. 4 (August 2008), 11–14.

⁷³ Kan Yabin [阚亚斌], “Three-in-One Graphic of Tactical Decision-Making in Anti-Ship Missile Attack” [反舰导弹攻击三位一体图形化战术决策], *Fire Control and Command Control* [火力与指挥控制] 30, no. 6 (October 2005), 58–61, 66.

⁷⁴ “Near Seas or Far Ocean—An Investigation of the Usage of Chinese-Made Air Defense Destroyers” [近海还是远洋—国产防空护卫舰的使用探讨], *Modern Ships* [现代舰船], 12B (December 2007), 6–10.

⁷⁵ See Tang Baodong [唐保东], “U.S. Intensifies Weaving of a New ‘Space Net’—From TMD and NMD to CMD” [从TMD、NMD到CMD—美国加紧编织新‘天网’], *Liberation Army Daily* [解放军报], December 25, 2002, 12, available at <www.pladaily.com.cn/gb/pladaily/2002/12/25/20021225001174>.

⁷⁶ Min Haibo, Wang Shicheng, and Luo Dacheng [闵海波, 王仕成, 罗大成], “On Plasma Stealth Technology and Its Possible Application on Cruise Missiles” [等离子体隐身技术在巡航导弹上应用的可能性研究], *Electronics Optics & Control* [电光与控制] 14, no. 3 (June 2007), 150–153.

⁷⁷ For detailed analysis of Patriot-3 interceptors, see Zhi Xinyi [直心义], “The Assassin’s Mace of the ‘Alpha’ Line” [“阿尔法”连的撒手铜], *Aerospace Knowledge* [航空知识], no. 8 (2008), 15–17.

⁷⁸ Yan Daiwei, Gu Liangxian, Guan Qianshan, and Sun Ping [阎代维, 谷良贤, 管千山, 孙平], “Combat Effectiveness Modeling and Evaluation of Hypersonic Cruise Missiles” [高超声速巡航导弹作战效能建模与评论], *Acta Armamentarii* [兵工学报] 28, no. 6 (June 2007), 725–729.

⁷⁹ “There have been some breakthrough developments in China in theoretical research on high-pressure strong ion discharge non-equilibrium plasma source methods, and it is possible that the primary parameters of volume, mass, and energy consumption of available weak ion discharge non-equilibrium sources and reactors will be reduced by about five orders of magnitude to fulfill cruise missile plasma source index requirements.” Min Haibo et al. The U.S. Navy has developed a plasma stealth antenna using a U-shaped glass tube filled with low-pressure gas. When energized it performs its antenna function, transmitting and receiving. When deenergized it becomes virtually transparent to hostile electromagnetic signals. Both Russia and the United States have investigated plasma stealth technology for several years, with the Russians making the most theoretical progress (concepts to create a plasma stealth screen all around the surface of an aircraft, for example). In theory, this would reduce the aircraft’s RCS by 100 times. Stiff challenges remain in transferring theory to practice.

⁸⁰ For research supported by the National Defense Science and Technology Key Laboratory Fund, see Li Xiuhe and Chen Yongguang [李修和, 陈永光], “Research on Optimal Distribution of Radar Jamming Resources Based on 0-1 Programming” [基于0-1规划的雷达干扰资源优化分配研究], *Acta Armamentarii* [兵工学报] 28, no. 5 (May 2007), 528–532.

⁸¹ Thus protected, the attacking aircraft and missiles would rely on their own guidance systems at close range.

⁸² Zhang Xixiang [张锡祥], “Development and Applications of Ground-to-Air Radar Jamming System in Local Conflicts” [论地对空雷达干扰系统在局部战争中的作用及其发展], *Engineering Science* [中国工程科学] 2, no. 7 (July 2000), 55–65.

⁸³ An atmospheric duct is a horizontal layer in the lower atmosphere that affects the transmission of radio signals. See Zhao Yaming, Zhang Yonggang, and Jiao Lin [赵亚明, 张永刚, 焦林], “A Model for Evaluating the Operational Effectiveness of an Anti-Ship Weapon System Under Atmospheric Duct Conditions” [大气波导条件下反舰导弹武器系统作战效能评估], *Fire Control & Command Control* [火力与指挥控制] 33, no. 7 (July 2008), 89–92.

⁸⁴ Huang Jianming, Chen Wanqiang, and Zong Qiang [黄建明, 陈万强, 纵强], “Development and Application of Precision Guided Weapons” [精确制导武器发展及其应用], *Winged Missiles Journal* [飞航导弹] (September 2005), 33–36, 41.

⁸⁵ Millimeter wave (mmv) seekers are one of a variety of endgame seekers with substantial resolution of the target. Full body scans at 15 U.S. airports use mmv scanners.

⁸⁶ ONI, *The People’s Liberation Army Navy*.

⁸⁷ Tonglin, *A Sharp Lance of Modern Naval Warfare*, 325, 328.

⁸⁸ Not only does the U.S. Navy’s new E-2D airborne platform provide much better detection and tracking of smaller cross-section targets, but the new SM-6 interceptor on Navy ships will come equipped with a larger version of the U.S. Air Force AMRAAM active seeker used on the AIM-120 air-to-air missile. This will place China’s employment of longer-range LACMs as ship-killers at risk. For a prominent 2007 analysis that assumes this Chinese breakthrough had not yet occurred, see Michael McDevitt, “The Strategic and Operational Context Driving PLA Navy Building,” in Roy Kamphausen and Andrew Scobell, ed., *Right-Sizing the People’s Liberation Army: Exploring the Contours of China’s Military*, 500 (Carlisle, PA: Army War College, 2007).

⁸⁹ See Guan Shiyi, Zhu Kun, and Song Fuzhi [关世义, 朱坤, 宋福志], “Some Issues Regarding Cruise Missile Systems” [关于飞航导弹体系的几个问题], *Tactical Missile Technology* [战术导弹技术] (May 2004), 1–10. The authors are all from the CASIC Third Academy’s cruise missile design and systems engineering department.

⁹⁰ See Guan Shiyi [关世义], “Diversification in Cruise Missile Development” [向多极化发展的飞航导弹], *Missiles and Space Vehicles* [导弹与航天运载技术] (June 2002), 20–27; Guan Shiyi [关世义], “New Concept Cruise Missile Based on a Qian Xuesen Trajectory” [基于钱学森弹道的新概念飞航导弹], *Winged Missiles Journal* [飞航导弹], 1 (2003); Song Fuzhi [宋福志], “Countering Aircraft Carriers: Cruise Missiles Better Than Ballistic Missiles” [对抗航母—巡航导弹优于弹道导弹], *Tactical Missile Technology* [战术导弹技术] 4 (July 2006), 9–15. The authors are from the CASIC Third Academy’s cruise missile design and systems engineering department. For an argument against use of cruise missiles and in favor of sea-launched ballistic missiles to counter aircraft carriers, see Wang Zaigang [王在刚], “The Nemesis of Super Aircraft Carrier Battle Groups” [超级航母编队的克星], *Naval and Merchant Ships* [舰船知识] (January 2005), 24–27. See also Li Benchang and Li Zhisheng [李本昌, 李智生], “Some Thoughts on Development of Our Country’s Submarine Launched Cruise Missiles” [对发展海防巡航导弹的一些看法], *Missiles and Space Vehicles* [导弹与航天运载技术], no. 6 (2002), 16–19.

⁹¹ Sun Zailong and Liu Huitong [孙再龙, 刘会通], “Requirements of Detectors for Infrared Imaging Guidance” [红外成像制导对探测器的需求], *Infrared and Laser Engineering* [红外与激光工程] 37, no. 3 (June 2008), 378.

⁹² While “it is also necessary to take into consideration the factor of target motion,” there are more options for doing so. But “since the atmospheric transmission in the horizontal route on the sea surface is poor, ground targets usually do not have artificial heat sources, and object contrast is low, it is required that the temperature sensitivity be relatively high. The NETD [noise equivalent temperature difference] must be lower than 0.1 K [Kelvin]. The imaging frame frequency of a subsonic missile may be 50 Hz, but the frame frequency of a supersonic missile must be 100 Hertz (Hz) or higher. In view of the complexity of the sea and ground backgrounds, and in order to acquire relatively high numbers of target pixels for target identification, it is required that the space resolution ratio be relatively high. The space resolution ratio for seaborne targets must be better than 0.3 mrad [milliradians], and the requirement for the resolution ratio for ground targets is even higher.” *Ibid.*, 378.

⁹³ For detailed analysis, see Andrew S. Erickson and Gabriel B. Collins, “Spaceplane Development Becomes a New Dimension of Emerging U.S.-China Space Competition,” *China SignPost* [洞察中国], no. 61, available at <www.chinasignpost.com/wp-content/uploads/2012/08/China_SignPost_62_Spaceplane-Development-Becomes-a-New-Dimension-of-Emerging-U.S.-China-Space-Competition__20120816.pdf>.

⁹⁴ Among various sources, see Che Jing and Tang Shuo, “Research on Integrated Optimization Design of Hypersonic Cruise Vehicle,” National Natural Science Foundation study, August 21, 2006. The authors are from the Northwestern Polytechnic University’s College of Astronautics, which hosts a GAD-funded laboratory on flight vehicles.

⁹⁵ Zhan Hao, Sun Dechuan, and Xia Lu [詹浩, 孙得川, 夏露], “Preliminary Design for Soaring Hypersonic Cruise Vehicle” [滑跃式高超音速巡航飞行器设计初步研究], *Journal of Solid Rocket Technology* [固体火箭技术] 30, no. 1 (2007), 5–8. The authors are also from the Northwestern Polytechnic University’s College of Astronautics.

⁹⁶ Chen Xiang, Chen Yuchun, Tu Qiuye, Zhang Hong, and Cai Yuanhu [陈湘, 陈玉春, 屠秋野, 张宏, 蔡元虎], “Research on Performance of Air-Turbo Rocket” [空气涡轮火箭发动机的性能研究], *Journal of Projectiles, Rockets, Missiles, and Guidance* [弹箭与制导学报] 29, no. 2 (April 2009), 162–165. The authors

are from the Northwest Polytechnic University's School of Power and Energy. Li Huifeng, Chen Jindong, Li Naying [李惠峰, 陈金栋, 李娜英], "Research on Midcourse Navigation of Hypersonic Cruise Air Vehicles" [高超声速巡航飞行器中制导研究], *Modern Defense Technology* 34, no. 6 (November 2006), 61–65. The authors are from the Beijing University of Aeronautics and Astronautics (BUAA) Space College.

⁹⁷ Liu Yang [刘杨], "The Requirements of Special Anti-Ship Cruise Missiles from the Perspective of Surface Ship Development" [从水面舰艇的发展看特种反舰导弹需要], *Winged Missiles Journal* [飞航导弹], no. 6 (2008), 41–44.

⁹⁸ Gu Chaoqi, Zhou Deyun, and Li Jianbo [顾潮琪, 周德云, 李建波], "Optimizing the Penetration Altitude of Cruise Missiles Based on Combat Efficiency" [作战效能的巡航导弹突防高度优化], *Fire Control and Command Control* [火力与指挥控制] 33, no. 2 (February 2008), 79–81.

⁹⁹ Qian Jin, Xu Xingzhu, and Liu Zhaoyun [钱进, 徐兴柱, 刘赵云], "A Preliminary Analysis of Cruise Missiles Based on Combat Technology" [巡航导弹航迹规划技术初探], *Winged Missiles Journal* [飞航导弹], no. 1 (2008), 16–19.

¹⁰⁰ Liu Zhiqiang and Bi Kaibo [刘志强, 毕开波], "Selection and Analysis of Control Laws for Combined Subsonic/Supersonic Anti-Ship Missiles" [亚超结合反舰导弹控制规律的选择与分析], *Fire Control and Command Control* [火力与指挥控制] 30, no. 6 (October 2005), 55.

¹⁰¹ For a detailed explanation, see Greg Chaffin, "Building an Active, Layered Defense: Chinese Naval and Air Force Advancement—An Interview with Andrew S. Erickson," *Policy Q&A*, National Bureau of Asian Research, September 10, 2012, available at <<http://www.nbr.org/research/activity.aspx?id=272>>.

¹⁰² Ibid.

¹⁰³ Mark A. Stokes, *China's Strategic Modernization*, 81.

Chapter Six

¹ See William S. Murray, "Revisiting Taiwan's Defense Strategy," *Naval War College Review* 61, no. 3 (Summer 2008), 13–38. See also David A. Shlapak et al., *A Question of Balance: Political Context and Military Aspects of the China-Taiwan Dispute* (Santa Monica, CA: RAND, 2009), 31–51, available at <www.rand.org/content/dam/rand/pubs/monographs/2009/RAND_MG888.pdf>. From Taiwan's perspective, air parity would certainly be preferred to not being able to fly, and its possibility might just dissuade China from starting any campaign that threatened to be challenging. The "porcupine" strategy that William Murray proposes, as with any other option that increases uncertainty in Chinese planning, would benefit Taiwan. Specific measures could include hunkering down via hardening aircraft shelters to protect aircraft until Chinese missile holdings are exhausted, greatly improving rapid runway repair and increasing Chinese attack size by greatly expanding the number of alternate runways at 40 airfields and airports in Taiwan. What little Taiwan has invested in Patriot (190 or so interceptors) would be best placed around airbases rather than cities. Doubling that number would soak up nearly 200 missiles, in theory.

² A simple juxtaposition of numbers ignores key factors. The range of the ASCMs matters significantly. One ASCM can neuter or destroy one target. Targeting also matters. ASCMs without a firing solution are useless. How each side can develop its firing solutions is likewise important. Nevertheless, it is important for the U.S. military, which has not faced a serious A2/AD threat since the end of the Cold War, to consider how rapidly China's cruise missile numbers have increased.

³ There are many variables at work here, not least China's maintaining the necessary volume of fire, which may be impeded by poor C3I, bomb damage assessment, and perhaps even U.S. attacks on delivery systems. The important challenge for China is to impede takeoff, if only temporarily, so Taiwan aircraft are less capable of impeding Chinese offensive aircraft strikes.

⁴ Once released from the mission of bombing airbases, Chinese aircraft could focus on reducing Taiwan's sortie generation. Missile attacks leverage the effectiveness of PLAAF air strikes, reducing air defense requirements and increasing the weight of subsequent strikes against shelters, aircraft in the open, and hangars.

⁵ Mark A. Stokes, "The Chinese Joint Aerospace Campaign: Strategy, Doctrine, and Force Modernization," in *China's Revolution in Doctrinal Affairs*, ed. James Mulvenon and Daniel Finkelstein, 256 (Alexandria, VA: CNAC Corporation, 2005).

⁶ "Shock and paralysis" come from Mark Stokes; he attributes the notion to Chinese strategists. Perhaps older Chinese strategists picked it up after attending the Soviet Union's Voroshilov General Staff Academy. There one learned, for example, that "success in air operations is ensured by delivering surprise mass initial strikes on enemy airfields [that] create favorable conditions for effective actions of friendly forces and better results of actions against enemy airfields." Students were taught the value of increasing the initial weight of the first blow to create chaos and paralysis, thereby exploiting the "initial period of war." In effect, they were taking a lesson from von Moltke that "no plan of operations can look with any certainty beyond the first meeting. . . ." In effect, shock and paralysis is not meant to achieve success in the initial period but rather to adjust the initial conditions so as to predetermine a favorable outcome. These quotations are taken from Dennis M. Gormley, *Double Zero and Soviet Military Strategy: Implications for Western Security* (London: Jane's, 1988), 119–125, 159.

⁷ For details and further analysis, see Michael S. Chase and Andrew S. Erickson, "The Conventional Missile Capabilities of China's Second Artillery Force: Cornerstone of Deterrence and Warfighting," *Asian Security* 8, no. 2 (Summer 2012), 115–137.

⁸ Mark A. Stokes, "Expansion of China's Ballistic Missile Infrastructure Opposite Taiwan," *AsiaEye*, April 18, 2011, available at <<http://blog.project2049.net/2011/04/expansion-of-chinas-ballistic-missile.html>>.

⁹ OSD, *China Military Report 2011*, 2, 30.

¹⁰ OSD, *China Military Report 2010*, 66.

¹¹ Ibid.

¹² Rich Chang and J. Michael Cole, "China aiming 200 more missiles at Taiwan: MND," *Taipei Times*, September 4, 2012, available at <www.taipetimes.com/News/front/archives/2012/09/04/2003541913>.

¹³ OSD, *China Military Report 2009*, 66.

¹⁴ CEP is the radius of the circle within which a warhead will land at least 50 percent of the time. "China Tests New Land-Attack Cruise Missile," *Jane's Missiles and Rockets*, October 1, 2004.

¹⁵ Whether Taiwan's air force could be destroyed by China's missiles alone is a matter of intense debate. If not, then the PLAAF becomes a critical factor in the outcome of any conflict. John Lewis and Xue Litai, in *Imagined Enemies*, certainly believe so. Even more importantly, Soviet-era planners abstained entirely from the notion that missiles alone could succeed in any type of knock-out blow against NATO airbases. In the so-called air operation, Soviet planners intended to execute two to three waves of attack (consisting of ballistic missiles presumed accurate enough to make cuts in runways to impede the launch of U.S. aircraft to meet Soviet aircraft in air-to-air battles), with missiles leveraging the effectiveness of aircraft (each of which carried at least seven times the payload of missiles). Freed from having to meet U.S. aircraft, Soviet aircraft could attend to delivering crippling blows on NATO airfields. As for pulses of power, they relate to waves (two to three) of attacking aircraft preceded by leveraging attacks by missiles. For an appraisal of the Soviet air operation, see Gormley, *Double Zero and Soviet Military Strategy*, 119–127. Lewis and Xue quote a PLA officer as stating, "We can maintain air domination if the strategic rocket forces can paralyze the enemy's air force and naval aviation." The paralysis of Taiwan's air force is a temporary phenomenon; the killing blows come from air domination, especially if the PLAAF has "enough precision-guided munitions." This is certainly consistent

with the recent RAND report. It depended critically on the number of aircraft a carrier could launch in a given unit of time. See John Lewis and Xue Litai, *Imagined Enemies: China Prepares for Uncertain War* (Stanford, CA: Stanford University Press, 2006), 260–261.

¹⁶ According to “Taiwan—Air Force,” *Jane’s World Air Forces*, March 1, 2013, all Taiwan’s Mirage 2000 air-defense aircraft (roughly 60) are housed at Hsinchu Air Base, while two other bases (Chiayi and Hualien) support around 120 F-16 air-defense/attack aircraft.

¹⁷ Taiwan will argue, presumably, that it will receive enough warning to reposition its “strategic reserve” of aircraft to secure locations—Hualien, and Ta-Shan.

¹⁸ LACMs may well be more accurate than ballistic missiles. Why pulses of fire? Because missiles leverage the effectiveness of aircraft, their interaction is coordinated from a timing standpoint (missiles arriving first to pin down Taiwan’s air force and aircraft following up with more telling blows). This is likely to come in waves of missile/air, perhaps two to three on the first day. Obviously, it could be planned differently, but this is what the Chinese learned from their Soviet-era brethren. Xiaobing Li, in his *A History of the Modern Chinese Army* (Lexington: University of Kentucky Press, 2009), 129, writes, “Of all the services, the air force most closely followed the Soviet doctrine, tactics, and training.”

¹⁹ “A Number of Issues in Joint Operations with Cruise Missiles and Operational and Tactical Missiles,” *Kanwa Defense Review*, October 1, 2005, 48. Also see Shlapak et al., especially chapter 4, for specialized roles for Chinese LACMs against Taiwan targets.

²⁰ Shlapak et al., chapter 4.

²¹ Authors’ interview with a senior Taiwan official, April 2008, Monterey, CA. Targets vulnerable to LACMs but not SRBMs include aircraft housed in mountain revetments with doors at the base of the mountain. These dictate low-level attacks. LACMs can more accurately deliver submunitions and biological and chemical payloads compared with ballistic missiles. The most vulnerable aim point for a hardened shelter is the shelter door. Low-flying LACMs are preferred in this regard, too, because of their angle of attack and accuracy; even if they fail to penetrate the door, striking it would probably collapse it sufficiently to delay departure of aircraft, leading to a temporary functional kill.

²² “A Number of Issues in Joint Operations with Cruise Missiles and Operational and Tactical Missiles,” *Kanwa Defense Review*, October 1, 2005, 48. Also see Mark A. Stokes, *China’s Strategic Modernization*, 81.

²³ Minnie Chan, “Old Jets Converted into Cruise Missiles Could Hit U.S. Ships,” *South China Morning Post*, May 12, 2007. A study conducted by the Pentagon’s Defense Advanced Research Projects Agency showed that effective cruise missile defenses against a salvo of 200 LACMs would require an investment of \$475 million, or \$4 million per kill. And while the study assumed that the defense had the necessary ingredients to handle such salvo attacks, the consequence of such an attack would severely diminish inventories of such high-cost interceptors, thereby compromising other missions. See Gregory DeSantis and Steven McKay, *Unmanned Aerial Vehicles: Technical and Operational Aspects of an Emerging Threat* (Arlington, VA: PSR-Veridian Corporation, 2000), 9.

Chapter Seven

¹ This section focuses on LACMs because they apply more clearly than ASCMs to the sole export control (nonproliferation) mechanism, the MTCR, which deals with missiles capable of carrying weapons of mass destruction. Most of the world’s global inventory of ASCMs are short range and carry small payloads still sufficient to deal with platforms at sea.

² Taiwan received its mission planning technology and expertise from the United States. Pakistan got help, and possibly complete systems (perhaps unassembled), from China. Iran received assistance from China. South

Korea may be the closest to having a purely indigenous set of LACM programs (with four missile programs with ranges from 500 to 1,500 km) but it also made attempts to acquire advanced stealthy cruise missiles from the French in the 1990s. The United States has also furnished Tomahawk Land-Attack Missiles (TLAMs) to the UK, Spain, and Australia. Tokyo likely hopes that Washington will make a “rare exception” to the MTCR to let them receive such Category I missiles.

³ Iran is unlikely to acquire low-observable LACMs from China. At present, the U.S. Navy defends against adversary ASCMs far better than any of the individual Service CMD capabilities. But large numbers of ASCMs could test at-sea defenses, especially if they are fast (for example, BrahMos).

⁴ Robert Hewson and Andrew Koch, “Pakistan Tests Cruise Missile,” *Jane’s Defense Weekly*, August 17, 2005, 4.

⁵ India plans to deploy BrahMos with each of its three military services. Regarding plans for a submarine-launched version, which requires the most demanding modifications, see “Indian Submarines May be Armed with BrahMos,” *Military News Agency* (Moscow), August 20, 2008, available at <www.lexisnexis.com/lnacui2api/api/version1/getDocCui?lni=4T88-PKN0-TX60-N0KW&csi=167603&hl=t&hv=t&hns-d=f&hns=t&hgn=t&oc=00240&perma=true>.

⁶ Walter C. Ladwig III, “A Cold Start for Hot Wars? The Indian Army’s New Limited War Doctrine,” *International Security* 32, no. 3 (Winter 2007/2008), 158–190.

⁷ See “The Ballistic Missile Context” and “Ballistic Missiles and Regional Competitions,” Gormley, *Missile Contagion*, for an overview of China’s proliferation of ballistic missiles.

⁸ “2004 Report to Congress of the U.S.-China Economic and Security Review Commission,” June 2004, 144.

⁹ Thomas G. Mahnken, *The Cruise Missile Challenge*, 16–17.

¹⁰ During the Iran-Iraq war, China began exporting HY-2 ASCMs to Iran in 1985, which caused the United States to protest and impose a temporary freeze on high technology exports to China. In the early 1990s it became clear that China had supplied Iran with HY-2 production, training, and testing technology and equipment to enable it to produce this ASCM. By the mid-1990s, media reports indicated that China had supplied Iran with C-802 ASCMs (the less capable C-801 had already been exported by China), which might require sanctions under U.S. law. Sanctions were never imposed for the C-802 exports, and China made promises to the United States in 1997 not to furnish more cruise missiles to Iran. For details, see “China’s Missile Exports and Assistance to Iran,” Center for Nonproliferation Studies, Monterey Institute of International Studies, available at <www.nti.org/db/china/miranpos.htm>.

¹¹ While there is no certainty on this issue, the Pakistani Raad has the look of a South African LACM.

¹² Prasun K. Sengupta, “Babur’s Flight,” *New Delhi Force*, September 9, 2005.

¹³ Prasun K. Sengupta, “Dr. Khan’s Second Wal-Mart,” *New Delhi Force*, April 2006.

¹⁴ Pakistan has not only depended extensively on Chinese and North Korean assistance in virtually all of its ballistic missile programs, but it has also repeatedly sought help from outside sources for far simpler military equipment than LACMs. There is little evidence that Pakistan possesses the aeronautical, electrical, mechanical, and computer engineering skills to produce all the critical components of such a missile program. More important, what separates the industrial from the developing world is the capacity to integrate technology components into complex systems that achieve repeatable results under often taxing operational environments. In this respect, Pakistan—and even far more advanced countries—comes up significantly short. Thus, in all likelihood, the only real question is the precise nature and extent of China’s assistance.

¹⁵ Gormley, *Dealing with the Threat of Cruise Missiles*, 82–83.

¹⁶ *Ibid.*, 83.

¹⁷ Alex Wagner, “Washington to Sanction China, Pakistan for Missile Cooperation,” *Arms Control Today* 31, no. 7 (September 2001), available at <www.armscontrol.org/act/2001_09/chinasept01.asp>.

¹⁸ Stephanie Lieggi, “China’s New Export Controls,” available at <http://cns.miis.edu/archive/country_china/chiexp/index.htm>.

¹⁹ Phillip C. Saunders, “Preliminary Analysis of Chinese Missile Technology Export Control List,” September 6, 2002, available at <http://cns.miis.edu/programs/eanp/pdfs/prc_msl.pdf>. For a translated list of Chinese new control regulations, see “Chinese Export Controls and Jiang Zemin’s Visit to the United States,” available at <http://cns.miis.edu/archive/country_china/chiexp/index.htm>.

²⁰ A cruise missile’s aerodynamic flight stability makes it an inherently better platform from which to deliver and disperse chemical and biological agents compared with a ballistic missile. It can travel at speeds of Mach 4 or better. The lethal area for a given quantity of biological agent delivered by a cruise missile can be at least 10 times greater than that of a ballistic missile. This differential has been demonstrated through extensive modeling and simulation. Gene E. McClellan, Pacific-Sierra Research Corporation, interview with authors, August 22, 1997, Arlington, VA.

²¹ The MTCR is, in effect, a supplier cartel. Membership does not automatically confer anything except membership in an exclusive club of states that adhere to nonproliferation goals and procedures. China has slowly shown evidence of more responsible nonproliferation behavior: it sought and gained entry to the Nuclear Suppliers Group in 2004, as will be noted.

²² Anupam Srivastava, “China’s Export Controls: Can Beijing’s Actions Match Its Words?” *Arms Control Today* 35, no. 9 (November 2005), available at <www.armscontrol.org/act/2005_11/NOV-China.asp>.

²³ Ibid.

²⁴ Also worthy of consideration is the use of the MTCR’s outreach activities to help China with its enforcement challenges. The good offices of the European Union should also be brought to bear in working with China on the problem.

²⁵ Victor Zaborisky, “Does China Belong in the Missile Technology Control Regime?” *Arms Control Today* 34, no. 8 (October 2004), available at <www.armscontrol.org/act/2004_10/Zaborisky.asp>.

Chapter Eight

¹ The PLAN appears to have concluded that the ASW mission can be largely ignored and possibly handled to a limited extent by other means (for example, sea mines and perhaps unmanned underwater vehicles), at least for now, and has gone “all in” regarding antisurface warfare.

² Direct quote from Murray, “China’s Undersea Warfare: A USN Perspective.”

³ O’Rourke, 38; Blasko, 154.

⁴ A Chinese assessment of global cruise missile development can be found in Dai Yanli, Wang Lu, and Xiao Weibin [戴艳丽, 王路, 肖伟炳], “Survey of Global Cruise Missile Developments in 2007” [2007年世界巡航导弹发展综述] in *2008 Yearbook in International Arms Control and Disarmament* [国际军备控制与裁军], ed. Li Genxin and Teng Jianqun [李根信, 滕建群], 131–137 (Beijing: World Affairs Press [世界知识出版社], 2008).

⁵ To be sure, it would be wrong to simply compare numbers of missiles and conclude that there is a “missile gap” in the Western Pacific. That is the same mistake others make in counting Chinese submarines and observing how badly U.S. submarines are outnumbered in the region. For instance, the United States can hold surface ships at risk with fast and lethal SSNs firing torpedoes—one shot, one kill with an Mk 48. The real issue could be the growing range of Chinese ASCMs (if indeed the ranges are growing) where surface ASCM shooters can linger in shallow waters or away from U.S. SSNs and take long-range salvo shots from increasing distances. Even that depends on good over-the-horizon targeting, which can be greatly complicated by electromagnetic

emission control and other measures. As above, it is a complex balance. This is not to downplay the significance of PRC deployment of ASCMs; it is merely to say that the force balance is not simply ASCM versus ASCM.

⁶ The vulnerability of Chinese cruise missiles to defenses differs for ASCMs and LACMs. The former are more vulnerable to detection by Navy E-2D aircraft linked to ship defenses. The latter are far less vulnerable because cruise missile defense is more difficult when trying to detect low-flying missiles in dense ground clutter.

⁷ These challenges must be kept in perspective, however. Protracted weapons development timetables are visible even in the world's most advanced militaries. Consider, for example, U.S. efforts to develop the F-35 and the Future Combat System.

⁸ Tai Ming Cheung, "Innovation and Stagnation During the Maoist Era," in *Fortifying China*, 22–51; Evan A. Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age* (Stanford, CA: Stanford University Press, 2003); Xie Gang [谢光] et al., eds., *The Contemporary Chinese Defense Science and Technology Sector* [当代中国的国防科技事业] (Beijing: Contemporary China Press [当代中国出版社], 1992); Evan S. Medeiros et al.

⁹ At the same time, the post-1989 arms sales ban has not prevented China from purchasing the 3-M-54E or the SS-N-22 from Russia, obtaining Tomahawk wreckage from Pakistan, or developing and fielding DH-10.

¹⁰ Indeed, while Sino-Russian defense ties since the end of the Cold War have remained robust and China has received many of its most advanced foreign weapons systems from Russia, this relationship is not without problems. Russia's military and security community debates the wisdom of arms transfers to China, and there are misgivings. While defense industrial complexes are eager to make money just to survive, policymakers have remained cautious regarding the types of weapons systems to allow for exports to China and worry about Chinese tendencies to exploit and even copy outright including the most advanced Russian designs. They have therefore continued to keep at least some restrictions on the level of technology transfers and tried to influence and even impose conditions on where the Chinese acquired weapons to be deployed to minimize any threats to Russia's security interests. Still, the Russian technology and weapons systems transferred to China have been numerous, diverse, and in many cases advanced. Li Chenghong, "Sino-Russian Military Technology Cooperation: Current Status, Problems and Responses."

¹¹ Timothy Hu, "China: Marching Forward," *Jane's Defence Weekly*, April 25, 2007.

¹² See, for example, Ian Easton and Mark A. Stokes, "China's Electronic Intelligence (ELINT) Satellite Developments: Implications for U.S. Air and Naval Operations," *Project 2049 Institute*, February 23, 2010, available at <<http://project2049.net/publications.html>>. See also OSD, *China Military Report 2009*, 49; Andrew S. Erickson, "Eyes in the Sky," *U.S. Naval Institute Proceedings* 136, no. 4 (April 2010), 36–41; Andrew S. Erickson, "Micro-satellites: A Bellwether of Chinese Aerospace Progress?" in *Down to Earth: Satellite Technologies, Industries, and Cultures*, ed. Lisa Parks and James Schwoch, 254–279 (New Brunswick, NJ: Rutgers University Press, 2012). This paragraph is a direct quotation from Murray, "China's Undersea Warfare: A USN Perspective."

¹³ "The great advantage of VLF signals is their ability to penetrate water to tactically useful depths. This means that a receiving submarine does not have to extend an antenna above the ocean's surface (and hence raise its risk of being detected by opposing radars) to receive its missile firing orders via VLF broadcast. Instead, the VLF radio signal can be received on a wire antenna, while the antenna and submarine remain fully underwater. Many of the most recent *Yuan* and *Song* class submarines have what appear to be 'bell mouth' openings at the top aft end of their sails from which wire antennas could be streamed. VLF targeting orders could convey the latitude and longitude of the target, the salvo size and composition of the attack, and the desired time of arrival of the missiles. On board computers could then determine the launch times and missile flight paths necessary to satisfy the orders. The submarine crew would only have to successfully enter that data into the missiles from the ship's fire control system, and then fire the missiles. This would require relatively low crew proficiency, and

minimal at-sea training. Much of the process could be practiced ashore in computer-assisted training facilities or even while alongside the pier. All of this is consistent with computer-based training facilities and scenarios demonstrated to Westerners at Qingdao submarine academy, and with ongoing PLAN submarine force levels of at-sea training.” Murray, “China’s Undersea Warfare: A USN Perspective.”

¹⁴ See Stokes, “The Chinese Joint Aerospace Campaign: Strategy, Doctrine, and Force Modernization,” for an excellent analysis of emerging command and control arrangements for such a combined missile and air campaign.

¹⁵ The first wave of any air operation is the easiest, but it is still a daunting planning and execution task. Once the war begins, chaos and complexity commence. It is commonplace to underestimate command and control, which the Chinese have only recently begun to take seriously from a joint standpoint. As retired U.S. Navy Captain Wayne P. Hughes emphasizes in *Fleet Tactics: Theory and Practice* (Suitland, MD: Naval Institute Press, 1986), 219, “The art of concentrating offensive and defensive power being complicated, it is easy to exaggerate the potential of the enemy to master it.” Since the late 1990s, the PLA has undertaken large-scale exercises and more recently it has begun to work on joint operations more seriously. Still, John Lewis and Xue Litai quote a PLA officer speaking candidly about such large-scale exercises: “The exercise is part of the PLA’s annual training, but its political significance is greater than its military significance.” Quoted in Lewis and Xue, *Imagined Enemies*, 261. The air and missile operation is only one of a multitude of joint operations that require command and control attention.

¹⁶ Initial U.S. use of cruise missiles in *Desert Storm* in 1991 was successful, but the air tasking order was a paper product produced on a 24-hour cycle. The coalition was also facing a decidedly inferior opponent.

¹⁷ Decisionmaking is not really important if there is no new information to use in making decisions (other than one’s own launch failures, and presumably one would otherwise just launch another missile at the next launch time). The key is reacting to new situations that require C2 and training. An orchestra only has one conductor, but militaries have far more decisionmakers within because they react to unanticipated developments. BDA will suggest what the military needs to react to. Without some means of BDA, China’s cruise and ballistic missile force will be far less effective than its numbers would indicate.

¹⁸ Forensic data may not have been collected and analyzed for a small number of Tomahawk launches.

¹⁹ It is true that the United States used TLAMs in huge numbers in *Desert Storm* without any previous experience yet achieved adequate results. But increased usage over time suggests how much better the United States became in using TLAMs in real combat. As for no previous experience, while that is true in regard to combat operations, the Tomahawk has been around since the 1960s. It was tested repeatedly over time, yet its first substantial use two decades later came up much shorter than subsequent use. Real combat improves weapons systems. Operation *Desert Storm*, which lasted roughly 5 weeks, employed 317 Tomahawks, and 420 were used in 4 days in Operation *Desert Fox* 8 years later. Twelve years after the first Gulf War, 1,375 were employed in Operation *Iraqi Freedom*. Additionally, the U.S. Harpoon ASCM achieved only a 50 percent reliability rate after 50 tests. See Gormley, *Missile Contagion*, especially chapter 6.

²⁰ One does not accumulate tacit expertise by reading documents, as Chinese analysts appear to do on a massive scale, but rather by active performance. Repeated testing is no substitute for real combat to prove that one can achieve the results that parametric analysis in peacetime might suggest.

²¹ These might include ballistic missiles, UAVs, and precision-guided munitions (PGM usually refers to shorter-range air-delivered munitions such as the JDAM).

²² For an American view of the chief challenges of such propulsion technology, see David M. Van Wie, Stephen M. D’Alessio, and Michael E. White, “Hypersonic Airbreathing Propulsion,” *Johns Hopkins APL Technical Digest* 26, no. 4 (2005), 430–436.

Appendix A

¹ Tai Ming Cheung, “Innovation and Stagnation During the Maoist Era,” in *Fortifying China*; Evan A. Feigenbaum, China’s Techno-Warriors; Xie Gang [谢光] et al., eds., *The Contemporary Chinese Defense Science and Technology Sector* [当代中国的国防科技事业] (Beijing: Contemporary China Press [当代中国出版社], 1992).

² Sun Yali [孙亚力], “A Discussion on the Development of China’s Surface-to-Air Missiles: An Interview with Surface-to-Air Expert Senior Colonel Wang Heping” [中国地空导弹发展访谈录——访地空导弹专家王和平大校], *Ordinance Knowledge* [兵器知识] (October 1998), 2–4; Xun Fu [逄抚], “Technology and Tactical Thinking in China’s Early Days of Anti-Ship Missiles” [中国早期反舰导弹的技术与战术思想], *Modern Ships* [现代舰船] (March 2005), 36–43.

³ Yu Yongbo et al., *China Today: Defence Science and Technology*, Vol. 1 (Beijing: National Defence Industry Press, 1993), 422.

⁴ Sun Yali, “A Discussion on the Development of China’s Surface-to-Air Missiles.”

⁵ Ibid.

⁶ Yu Yongbo et al., *China Today: Defence Science and Technology*, Vol. 2 (Beijing: National Defence Industry Press, 1993), 476–481.

⁷ Lin Changsheng, *Modern Weapons and Equipment of the People’s Liberation Army*, 185–188; Wang Wei, “Sharp Blade: Development of the PLA-Navy’s Anti-Ship Missiles,” 35; Writers Group, *The Biography of Nie Rongzhen*, 331–336.

⁸ Iris Chang, *Thread of the Silkworm* (New York: Basic Books, 1995), 211–215.

⁹ Ibid., 228–229.

¹⁰ Xie Guang [谢光] et al., *China Today: Scientific and Technological Undertakings of National Defence* [当代中国的国防科技事业], Book Two [下卷] (Beijing: Contemporary China Press [当代中国出版社], 1992), 62–99; Sun Xu [孙旭], “The Shining Chinese Missiles” [中国导弹光彩夺目], *Conmilit* [现代军事] (March 1999), 19; Hai Chao [海潮], “China’s Naval Conventional Weapons Tests (1)” [中国海军常规武器试验 (上)], *Shipborne Weapons* [舰载武器] (April 2005), 34–40.

¹¹ Hai Chao [海潮], “Conventional Weapon Testing in China’s Navy” [中国海军常规武器试验], *Shipborne Weapons* [舰载武器] (April 2005), 34–40.

¹² Xie Guang et al., 487–504; Writers Group, *The Biography of Nie Rongzhen*, 370–375.

¹³ Xie Guang et al., 63–64.

Appendix B

¹ This overview is in part adapted with permission from Mark A. Stokes, *China’s Evolving Conventional Strategic Strike Capability*, 48–50. The authors are indebted to Mark Stokes for his invaluable and comprehensive contributions to this section.

² “Third Academy’s Liu Er’qi Photo” [中国航天三院院长刘尔琦校友照片], *Harbin Institute of Technology Today*, November 20, 2010, available at <<http://today.hit.edu.cn/articles/2010/11-20/1116053052.htm>>.

³ In addition to serving as chief designer of the YJ-83/C-802 cruise missile, and possibly the C-701, Huang Ruisong [黄瑞松] was Third Academy director and is a member of CASIC’s Science and Technology (S&T) Committee. Other deputy directors include former 31st Research Institute Director Xue Liang [薛亮]. See “China Academy of Engineering, Missile Expert Huang Ruisong” [工程院院士导弹技术专家黄瑞松], *National University of Defense Technology Network*, February 23, 2004, available at <www.lovenudt.com/detail.asp?fileid=160>.

⁴ The 3rd Department has at least 15 offices responsible for general design, navigation and control, software, information systems, simulation, etc. See “Third Academy Recruitment Requirements” [航天科工集团三院

三部2010年需求毕业生信息], Beihang University Web site, December 1, 2009. See also “CASIC 2011 Work Committee Working Group Assembles for Discussion” [中国航天科工2011年工作会分组讨论发言集萃], *Zhige.net* [止戈网], January 27, 2011, available at <www.zhige.net/html/2011/0127/22229.html>.

⁵ Hu Wanhai [胡万海], for example, is deputy director of the Third Academy 3rd Department [航天三院总师] and cited as chief designer of an unnamed missile system. See <www1.btbu.edu.cn/cms/bencandy.php?fid=20&id=1320>. Senior 3rd Department designer and current Third Academy S&T Committee Deputy Director Liu Yongcai [刘永才] is believed to be senior designer of the DH-10. See “Liu Yongcai: Embracing the Song of the Wind” [刘永才: 胸怀大爱唱大风], *China Space News*, January 26, 2010. Yet another prominent cruise missile systems engineer is Feng Dawei [冯大伟], who is now a member of the Third Academy S&T Committee. She played a key role in the system demonstration and validation phase of a major cruise missile program, which lasted from 1995 to 1999. The system failed an initial flight test in 2001 and succeeded in May 2004. See “Aerospace Pioneer: Third Academy Third Department Systems Engineer and Designer Feng Dawei” [航天先锋: 航天三院三部型号系统主任设计师冯大伟], China National Space Administration Web site, December 19, 2006, available at <www.cnsa.gov.cn/n615708/n620172/n620642/87795.html>; and “China Successfully Tests Newly Developed Missile, Accurately Hits the Target” [中国研制的新型导弹试验获成功高精度命中靶标], *Renminwang*, August 16, 2004, available at <www.people.com.cn/GB/junshi/1079/2715875.html>.

⁶ “Yang Baokui: Leapfrogging of China’s Precision Weapons R&D” [杨宝奎: 中国精确制导武器研制实现技术跨越], China Academy of Sciences Web site, April 19, 2004, available at <www.cas.cn/xw/zjsd/200906/t20090608_644604.shtml>.

⁷ See Guan Shiyi, Zhu Kun, and Song Fuzhi [关世义, 朱坤, 宋福志], “Some Issues Regarding Cruise Missile Systems” [关于飞航导弹体系的几个问题], *Tactical Missile Technology* [战术导弹技术] (March 2004), 1–10. The authors are all from the CASIC Third Academy’s cruise missile design and systems engineering department. Guan Shiyi distinguishes cruise missiles into two types: *feihang daodan* [飞航导弹], which tend to be shorter-range antiship missiles, and *xunhang daodan* [巡航导弹], which are longer-range and often incorporate midcourse guidance systems such as TERCOM. See Guan Shiyi [关世义], “Diversification in Cruise Missile Development” [向多极化发展的飞航导弹], *Missiles and Space Vehicles* [导弹与航天运载技术] (June 2002).

⁸ As of mid-2010, the 31st Institute director was Zhao Wensheng [赵文胜]. Turbofan engine expert Liu Zhende [刘振德] serves as deputy director as well as director of the Institute’s S&T Advisory Committee. He formerly directed the 31st Institute’s 11th Office. See “Commemorating Aerospace Missile Engine Expert CASIC Third Academy 31st Institute Deputy Director Liu Zhende” [记航天弹用发动机专家, 航天科工集团三院所副所长刘振德], April 3, 2010, Western China Science Network, available at <www.kxwest.com/html/xueshujiailiu/8702.html>. Other prominent figures include Zheng Riheng [郑日恒]. Born in 1963, Zheng is a senior engineer within the 31st Research Institute and deputy chief designer of a new missile system. See <<http://hi.baidu.com/tribuna/blog/item/50087c3dab5273ed3c6d97df.html?cmtid/4567277b625e3cf80bd18731>>.

⁹ “Liu Xingzhou: Qualities of an Ordinary Scholar” [刘兴洲: 学者本色平常心], *China Space News*, December 12, 2003. See also “Third Academy: Multidirectional Future Planning, Brainstorming” [三院: 多方方针谋划未来 集思广益助力发展], CASIC Web site, March 31, 2009.

¹⁰ As of October 2010, Zheng Xin [郑辛] served as 33rd Institute director. Born in 1968, Zou Zhiqin directs the 33rd Research Institute’s 14th Research Lab and is responsible for INS systems. See “Examination of 33rd Institute Company Assets” [资产公司领导赴三院三十三所 调研], CASIC Asset Management Company Web site, October 25, 2010, available at <www.casiccapital.com>.

¹¹ “CASIC 2011 Work Committee Working Group Assembles for Discussion” [中国航天科工2011年工作会分组讨论发言集萃], available at <www.zhige.net/html/2011/0127/22229.html>.

¹² Zhou Ming [周明] is the current 35th Institute director.

¹³ “CASIC Successfully Joins Large Aircraft Program” [航天科工成功助力国产大飞机], December 30, 2010, available at <www.casic.com.cn/n103/n139/c237076/content.html>.

¹⁴ “Introduction to the Third Academy 8359 Institute” [航天三院8359研究所简介], Huazhong University, available at <www.kongrong.com/xiaoyuan/hubei/544756.html>.

¹⁵ See “Third Academy: 159 Factory General Assembly Line Waging Battle” [三院: 159厂总装线上演总攻战], CASIC Web site, December 10, 2010, available at <www.casic.com.cn/n103/n135/c226513/content.html>. See also <www.cva.org.cn/hyzj/ShowArticle.asp?ArticleID=1274>. The factory’s primary Web site is available at <www.bjhtxh.com/>.

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Mr. Gormley received a B.A. and M.A. in history from the University of Connecticut in 1965 and 1966, respectively, and attended Officer Candidate School at Aberdeen Proving Grounds, Maryland, where he was commissioned a Second Lieutenant in the U.S. Army Ordnance Corps, serving on Active duty from 1966 to 1969. Before joining Pacific-Sierra Research in 1979, he served in the U.S. Intelligence Community for 10 years, including 7 years as Head of Foreign Intelligence at the U.S. Army's Harry Diamond Laboratories, Washington, DC.

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Mr. Gormley is the author of over 100 publications, including the books *Missile Contagion: Cruise Missile Proliferation and the Threat to International Security* (Praeger, 2008) and *Dealing with the Threat of Cruise Missiles* (Oxford University Press for IISS, 2001). His journal articles have appeared in *Survival*, *Washington Quarterly*, *Arms Control Today*, *Bulletin of the Atomic Scientists*, *Nonproliferation Review*, *Orbis*, and many others. Among his publications are three commissioned monographs in the Proliferation Papers series published by the Institut français des relations internationales (Ifri) in Paris.

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China's military modernization includes ambitious efforts to develop antiaccess/area-denial (A2/AD) capabilities to deter intervention by outside powers. Highly accurate and lethal antiship cruise missiles and land-attack cruise missiles carried by a range of ground, naval, and air platforms are an integral part of this counter-intervention strategy. This comprehensive study combines technical and military analysis with an extensive array of Chinese language sources to analyze the challenges Chinese cruise missiles pose for the U.S. military in the Western Pacific.

"Cruise missiles are key weapons in China's A2/AD arsenal, providing a lethal precision-strike capability against naval ships and land-based targets. The authors use hundreds of Chinese language sources and expertise on cruise missile technology to assess China's progress in acquiring and developing advanced antiship and land-attack cruise missiles and to consider how the People's Liberation Army might employ these weapons in a conflict. Essential reading for those who want to understand the challenges China's military modernization poses to the United States and its allies."

—DAVID A. DEPTULA, Lieutenant General, USAF (Ret.), Senior Military Scholar,
Center for Character and Leadership Development, U.S. Air Force Academy

"This volume is a major contribution to our understanding of Chinese military modernization. Although China's ballistic missile programs have garnered considerable attention, the authors remind us that Beijing's investment in cruise missiles may yield equally consequential results."

—THOMAS G. MAHNKEN, Jerome E. Levy Chair of
Economic Geography and National Security, U.S. Naval War College

"This book provides an excellent primer on the growing challenge of Chinese cruise missiles. It shows how antiship and land-attack cruise missiles complicate U.S. efforts to counter China's expanding A2/AD capabilities and are becoming a global proliferation threat. The authors also demonstrate just how much progress China has made in modernizing and upgrading its defense industry, to the point of being able to develop and produce world-class offensive weapons systems such as land-attack cruise missiles. This book belongs on the shelves of every serious observer of China's growing military prowess."

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