Andrew S. Erickson and Jingdong Yuan

Antiaccess and China's Air-Launched Cruise Missiles

FOR THE PEOPLE'S LIBERATION ARMY (PLA) to confront a stronger opponent in local conflicts under modern, informatized conditions, the only path to victory—or at least to avoid defeat—would be to disrupt and deny access to U.S. forces and exploit their points of vulnerability with so-called assassin's mace weapons as necessary. This chapter examines the role of one such "silver bullet"—air-launched cruise missiles (ALCMs)—in the PLA's antiaccess strategy, and seeks to address the following questions:

- What has been China's development path with respect to ALCMs?
- What are the advantages of ALCMs vis-à-vis other means of delivery (e.g., surface ships and submarines) for various relevant scenarios?
- How are Chinese cruise missiles related to their Soviet/Russian counterparts?
- What are Chinese ALCM trends with respect to range, speed, and electronic warfare capabilities?

The chapter will analyze the role of ALCMs in support of the PLA objectives of dissuading and deterring U.S. intervention by disrupting and denying it access to the vicinity of the Taiwan Strait.

Cruise Missiles' Advantages and PLA Antiaccess Strategies

Chinese analysts increasingly recognize the potential for cruise missiles to serve as decisive long-range precision weapons in modern warfare. Cruise missiles are easy to maintain for extended periods in harsh environments because (unlike some missiles) they may be placed in canisters if desired. Like many other weapons, modern cruise missiles offer multiple launch options (land, sea, and air). This affords a "two-stage" form of delivery that extends the missiles' already substantial range. Cruise missiles need only rudimentary launch-pad stability, thus enabling shoot-and-scoot tactics. Because cruise missiles do not produce large infrared launch signatures, they are not detectable by space-warning systems, which makes postlaunch counterforce attacks problematic. Cruise missiles are also cheaper than airplanes—in effect, they allow the force employing them to avoid having to buy an aircraft that has to penetrate air defenses in order to deliver ordnance. Finally, because of their supersonic speed, small radar signature, and earth-hugging flight profile, cruise missiles greatly tax ground-based and airborne surveillance and tracking radars, thereby increasing the likelihood that they will successfully penetrate defenses.

Cruise missiles have potential advantages over ballistic missiles for a country such as China. Indeed, cruise missiles, together with ballistic missiles, will likely play a prominent role in what is described as the PLA's missile-centric strategies, especially in the Taiwan Strait war theater, where the Chinese military could put at risk U.S. targets in Guam, Okinawa, and at sea. Employed in salvoes (e.g., in a stream raid, a form of salvo on a single axis), perhaps in tandem with ballistic missiles, cruise missiles potentially could saturate or overcome defenses. A saturation attack would consist of a large number of cruise missiles arriving at a specific target in a short period in hopes of overwhelming defenses. Saturation could take a variety of forms, including the dispatch of more missiles than enemy radar systems or interceptors could handle.

There are two major varieties of cruise missiles, both of which may be air launched. Antiship cruise missiles (ASCMs), which can be launched from PLA Navy (PLAN) submarines, surface vessels, and aircraft, employ alternative targeting methods that often eliminate reliance on satellite surveillance capabilities. These include inertial navigation systems and radar and electro-optical sensors. Land-attack cruise missiles (LACMs), currently ground-launched by the Second Artillery and air-launched by the PLA Air Force (PLAAF), are long-range strategic strike weapons not currently deployed on PLAN surface ships, perhaps because they are redundant in regional scenarios and hence suggestive of extraregional offensive strike capability. LACMs, typically used against fixed targets, may also rely on similar targeting methods to ASCMs as well as terrain contour mapping and digital scene-matching area correlation technology.

Key Chinese ALCM Trends

China is working to deploy large numbers of highly accurate air-launched antiship and land-attack cruise missiles, the latter of which has figured prominently in regional military campaigns around the world since 1991. Cruise missiles are seen as a key to a short-duration, high-intensity military campaign against Taiwan as well as to inhibit U.S. intervention in such a contingency. According to the U.S. Department of Defense (DoD), "The PLA Navy has or is acquiring nearly a dozen ASCM variants. . . . The pace of ASCM research, development and production within China and procurement from abroad—primarily Russia—has accelerated over the past decade."[1]

China has developed its own advanced, highly capable ASCMs, the Yingji (Eagle Strike), or YJ-series, while also importing supersonic ASCMs from Russia for which there is no operational Western equivalent. China is capable of launching its ASCMs from a growing variety of land, air, ship, and undersea platforms, thus providing redundant multiaxis means of massing offensive firepower against targets at sea, or at least against their predicted locations. China has furnished its ASCMs with improved guidance and satellite navigation capabilities. A variety of platforms, including unmanned aerial vehicles (UAVs), may be increasing the already respectable accuracy and targeting capability of these weapons via data link. Still, over-the-horizon targeting remains a difficult challenge at present. Chinese researchers are studying how to best overcome (i.e., by saturating) Aegis defenses and target vulnerabilities. Chinese aviation training has become more diverse and realistic in recent years, with increasing focus on cruise missile operations.

China's most potent air-launched cruise missiles are LACMs. Operating in tandem with China's huge inventory of conventionally armed ballistic missiles, LACMs offer the PLA the ability to threaten Taiwan's capacity to use its previously superior air force to thwart Chinese attack options. Chinese planners emphasize the shock and paralytic effects of combined ballistic and LACM attacks—in large volumes or salvos—which could overwhelm enemy missile defenses and enable follow-on aircraft strikes. They view LACMs as particularly effective against targets that require precision accuracy (e.g., airfield hangars and command-and-control sites). As Mark Stokes (assistant U.S. air attaché in Beijing, 1992–95), 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.[2]

China still lags in its capacity to realize the full potential of precision delivery systems such as cruise missiles. Shortcomings remain in intelligence support, command and control, platform stealth and survivability, and post-attack assessment, all of which are critical to mission effectiveness. Time and dedicated effort will increase China's ability to employ LACMs even in challenging combined arms military campaigns.

Chinese ALCM Capabilities

Chinese military dictionaries categorize cruise missiles based on their launch platform, although most (or at least their variants) may be launched from multiple launch platforms. Many of China's cruise missiles may be launched by aircraft; several types, including some LACMs, may only be launched from that platform. This is a distinction with a difference: with the exception of some newer LACMs, a cruise missile's limited range typically necessitates that its launch platform approach within 100–200 km of a target, thereby tying the missile's effectiveness to that platform's performance parameters (particularly stealth). In this sense, ALCMs have trailed their submarine and even surface vessel–launched counterparts, both of which boast far greater range unrefueled, while China's conventionally powered submarines are potentially far more survivable as well.

Nevertheless, this volume demonstrates that while China's missile systems remain far superior to its aviation counterparts and that this disparity seems unlikely to narrow soon in many respects, Chinese military aviation is gradually improving. Moreover, some LACMs, including the indigenous DH-10, promise to have ranges in excess of 2,000 km, thereby enabling significant strike reach even if launch platforms remain within a protected "bastion" far closer to China's shores. For all these reasons, it is time to revisit the evolution, role, and potential of Chinese ALCMs. For the attributes of China's major air-launched cruise missiles, see table 1.

Antiship Cruise Missiles

China has perhaps made the greatest progress to date regarding ASCMs. Here Beijing has truly developed comprehensive indigenous capabilities that approach world-class levels in many areas. PLAN ASCM programs include a variety of surface-, subsurface-, and air-launched weapons. This mixture of

Table 1: Performance Parameters of Major Chinese Air-Launched Cruise Missiles (ALCMs)

Name	Launch Platform/Type	Range (km)	Payload (kg)	Speed (sub/super)	Guidance (inertial/terminal)
LAND-ATTACK CRUISE MISSILES (LACMs)					
YJ-63/KD-63[1]	Air	200–500	500	Sub	INS/Sat/Active/Passive; electro-optical terminal guidance
DH-10/CJ-10[2]	Ground, air (?)	1,500–2,500	500	Sub	INS/TERCOM/Probable DSMAC for terminal guidance
YJ-100[3]	Air	1,500–2,000	500	Sub	INS/TERCOM
YJ-91[4]	Air, ship	120	90	Super	Passive/Antiradiation
KD-88[5]	Air	180–200	165	Sub	Inertial; active terminal guidance
ANTISHIP CRUISE MISSILES (ASCMs)					
Name	Launch Platform/Type	Range (km)	Payload (kg)	Speed (sub/super)	Guidance (inertial/terminal)
YJ-83[6]	Ground, ship, air, sub	160	165–250	Sub	INS, data link, active/passive radar

Sources:

1. Office of the Secretary of Defense (DoD), *Military and Security Developments Involving the People's Republic of China 2010*, Annual Report to Congress (Washington, DC: Office of the Secretary of Defense, 16 August 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*, 20 October 2008, http://www.sinodefence.com/airforce/weapon/kd63.asp.
2. DoD, *Military and Security Developments*, 31.
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4. The YJ-91 is based on the Russian Kh-31P. See DoD, *Military and Security Developments*, 31; "YingJi-91 (Kh-31P) Anti-Radiation Missile," *China's Defence Today*, 20 October 2008, http://www.sinodefence.com/airforce/weapon/kh31.asp.
5. The KD-88 is a derivative of the YJ-83, roughly comparable to the U.S. land-attack variant of Harpoon. See DoD, *Military and Security Developments*, 31; "KD-88," *China's Defence Today*, 26 October 2008, http://www.sinodefence.com/airforce/weapon/kd88.asp.
6. The YJ-83 is a third variant of the basic YJ-8 ASCM (export designation of C-803). See DoD, *Military and Security Developments*, 3; Bill Gertz, "Chinese Missile Has Twice the Range U.S. Anticipated," *Washington Times*, 20 November 2002; and "YJ-83," *Missile Threat.Com*, http://www.missilethreat.com/cruise/id.67/cruise_detail.asp. The air-launched version is sometimes referred to as the YJ-83K.

ASCMs gives the PLAN flexibility and tactical depth, utilizing 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.

The C-801 (YJ-8/HY-5)/802 (YJ-83) and C-802 (YJ-82) series is currently the backbone of China's ASCM inventory. It has a flight speed of Mach 0.9 and an operational range of 8 to 42 km. Strongly resembling and influenced by (though, according to one source, not reverse engineered from) France's MM38/MM39 Exocet, the C-801 is employed by the PLAAF JH-7 fighter. According to Chinese sources, one C-801 can immobilize a 3,000-ton destroyer and thereby render it a mission kill. This is a reasonable assessment: a C-801 carries a 165 kg semi-armor-piercing warhead, which is the same size as the Exocet, and there are ample examples of that size warhead disabling destroyers or frigate-sized warships.[3]

Developed by China Haiying [Sea Eagle] Electro-Mechanical Technology Academy (CHETA, alternatively known as the 3rd Space Academy), the C-802 is based on the C-801 but employs a different rocket motor, a turbojet with paraffin-based fuel. 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) and its range has been increased to 15–120 km. Its speed is Mach 0.9, and it skims the sea at an altitude of 20–30 m. The major difference from France's Exocet, on which it is closely modeled, is the "installation of a rudder flight control system on the bottom."[4]

According to its manufacturer, the China National Precision Machinery Import and Export Corporation, the C-802A export variant 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-class destroyer with a radar cross section of at least 3,000 square meters. The C-802A can be launched from air-, ship- and land-based platforms. It features "multiple flight path[s] and waypoints, sea skimming flight altitude, multiple anti-jamming capabilities . . . fire and forget . . . and over-the-horizon attack [capabilities]." The C-802A's range is 15–180 km. It has up to four attacking paths with up to three 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 or 7 m in terminal phase. For guidance, it uses strapdown intertial navigation system, a frequency agility radar, and digital control to achieve a single-shot kill probability of 90 percent. Its response time is 9 minutes cold, 30 seconds hot. The C-802A is 6.383 m long and 0.360 m in diameter, with a wingspan of 1.220 meters and a weight of 800 kg. Its 190 kg semi-armor-piercing blast warhead employs an electromechanical contact delay fuse.[5]

Chinese air-launched ASCMs also include the third-generation YJ-83K (C-803), 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. In September 2005 China unveiled a new ASCM known as the YJ-62, exported as the C-602. Propped alongside a much smaller YJ-82 (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 kn. The Office of Naval Intelligence (ONI) states that the "subsonic, sea-skimming" YJ-62 has a range of approximately 278 km and is "designed to sink or disable medium to large size ships."[6] According to Scott Bray, senior intelligence officer-China, 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."[7]

China has also reportedly acquired both variants of Russia's greater than Mach 2 Zvezda-Strela Kh-31 (AS-17 "Krypton") 70–200 km-range ramjet-powered sea-skimming missile. Following a joint program with Russia, China apparently has produced them indigenously (perhaps initially under license) as the YJ-91 and -93 variants.[8] China is also believed to have introduced the antiship radiation missile (ARM) variant, Kh-31A, capable of targeting a variety of maritime targets. The Kh-31A is expected to reach speeds of Mach 3.5 with an extended target range of 130 km, depending on cruise altitudes.[9] The PLAN's Sukhoi Su-30MK2 Flanker fighters, as well as perhaps its JH-7As, are reportedly fitted with the Kh-31. Russia specifically designed the Kh-31P passive high-speed anti-radiation (as opposed to Kh-31A active radar) version to assault Western radar systems (e.g., the U.S. Navy's SPY-1 and the U.S. Army's Patriot radar).

LACMs of the YJ Series

Other than building an LACM from scratch, the most direct route to developing one is to convert a simpler ASCM into a more complex land-attack system. China has explored precisely this route to developing cruise missiles for attack over land. China has turned to its own HY-2 (Haiying-2) ASCM, named Silkworm by Western intelligence, which has a range of about 100 km, as a test bed for a much more potent and capable LACM, the YJ-63, an air-launched LACM developed by CHETA and carried by the H-6D bomber. This missile possesses two to five times the range of its progenitor, the Silkworm, and, of course, true land-attack capability.[10]

The YJ-63.

At present, China's principal long-range air-launched weapons system is the YJ-63 (C-603) air-launched LACM. It was designed to provide standoff air-launched precision strike capabilities for PLAAF's H-6H bomber.[11] Some sources claim that the YJ-63 was developed from the HY-2 ship-to-ship or coast-to-ship cruise missile, which was subsequently replaced by a more advanced version, the YJ-6 (C-601). The latter antiship missile was employed on the naval variant of H-6 medium bomber, designated the H-6D. Both the H-6D naval variant and the H-6H PLAAF variant carry two cruise missiles launched from wing pylons. Reportedly deployed in 2004–5, it was apparently displayed during the 2005 Sino-Russian Peace Mission joint exercises. The YJ-63 is said to use a combined inertial and GPS/GLONASS mid-course guidance system and an electro-optical television system for the terminal attack phase, achieving a circular error probable (CEP) of 10–15 m while carrying a payload of 500 kg.[12] A later or perhaps slightly different version of the YJ-63, called KD-63, appears to have a solid rather than a glass window, implying that the KD-63 may employ a terminal guidance system other than an electro-optical television one, or that it may simply depend exclusively on satellite guidance updates of its inertial reference system.

The YJ-63's reported range varies from 200–500 km. This variance is not surprising for an ALCM: the actual range capability of aircraft-launched LACMs can be significantly longer than what manufacturers typically advertise publicly. Nothing is publicly known about the YJ-63's turbojet engine (called the FW41-B by one source), but it should propel the missile at a speed of roughly Mach 0.7. The YJ-63's lineage from the Silkworm missile is evident in available photographs of the missile. Looking very much like the HY-2 or its air-to-ground cousin, the YJ-6 (C-601), and the turbojet-equipped HY-4, the YJ-63 has a large round body with a correspondingly round nose. Its turbojet engine inlet, like the HY-4's, is located under the missile's body just behind the large delta wings. Like the HY-4, the YJ-63's tail control surfaces are arranged in an X-shape pattern. Open sources furnish little of value with regard to the dimensions of the YJ-63, but given its lineage, one might expect the missile's length to be just under 7.5 m, its diameter about 0.75 m, and its wingspan, 2.4 m. The overall weight is estimated to be in the range of 2,500 kg. Conceivably, the YJ-63 could be stretched to accommodate additional fuel plugs that would permit it to achieve a range of roughly 700 km without reducing the existing conventional payload of 500 kg. But what would really improve the range performance of first-generation Chinese LACMs would be a highly fuel-efficient turbofan engine.

The Dong Hai-10 (DH-10).

The challenge of monitoring LACM development programs is no more apparent than with the sudden emergence of China's DH-10, which was reported to have been tested for the first time in fall 2004. As described by a *Jane's* writer in 2004, the DH-10 is a ground-launched second-generation LACM with a range of 1,500 km. Conversely, DoD reports that the DH-10's range is 1,500+ km, and 200–500 missiles are already available for use on 45–55 ground-based launchers.[13] The missile is likely guided to its target by an integrated inertial/GPS reference system supported by a terrain contour mapping and digital scene matching for terminal homing, the combination of which should provide a 10 m CEP.[14] From the general appearance of the DH-10 in Internet pictures, the missile's lineage seems related to the Russian Kh-55, although its range is only half that of the Kh-55's.

While DoD's 2010 report refers to the DH-10 as "ground-launched," an air-launched variant may be developed as well.[15] DoD also states that "China is upgrading its B-6 bomber fleet . . . with a new variant which, when operational, will be armed with a new long-range cruise missile."[16] The report indicates that the B-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.[17]

Conclusion

Chinese air-launched ASCM and LACM development, like that of cruise missiles overall, has progressed rapidly. These efforts have yielded a significant increase in PLA capabilities. ASCMs and LACMs, along with other systems, are key components in Chinese efforts to develop antiaccess/area denial capabilities that will increase the costs/risks of U.S. forces operating along China's sensitive maritime periphery, including in a Taiwan contingency. LACMs offer China new options for conventional strike. These apply most to Taiwan scenarios, where ground-, sea-, and air-based systems could be employed, but are also of concern to Japan and the U.S. territory of Guam and provide a limited capability wherever PLAN aircraft can deploy. As their launch platforms improve steadily, ASCMs are increasingly poised to challenge U.S. surface vessels, particularly in situations in which the quantity of their fires is sufficient to overwhelm Aegis air-defense systems through saturation tactics. China plans to employ cruise missiles in ways that exploit synergies with other strike systems and that can allow cruise missiles to degrade air defenses and command and control to enable air strikes. Defenses and other responses to the People's Republic of China's cruise missile capabilities exist but will require greater attention and a focused effort to develop countermeasures and other responses.

While ALCMs have many advantages for China, their optimal employment requires accurate and timely intelligence; suitable and ideally stealthy delivery platforms; mission planning technology; command, control, and communications systems; and damage assessment. China has incorporated antiship and land-attack cruise missiles into its force structure, employing ground, air, surface, and subsurface means of delivery for particular missions. But to realize fully the potential benefits of such precision delivery systems, China will likely have to invest further in all the relevant enabling technologies and systems required to optimize cruise missile performance.

For now, however, China still lags in its capacity to orchestrate the delicate timing involved in coordinating combined missile and air strikes. China will also require time and dedicated effort to develop the confidence to rely on its ASCMs and LACMs to perform as imagined, particularly in challenging combined arms military campaigns. This is particularly true of air-launched variants, which are tethered to the performance parameters of their launch platforms.

Two caveats are particularly important to keep in mind. Force modernization depends not just on relentlessly building up missile inventories. Even more important is developing the capacity to extract as much value from these weapons as the order of battle suggests they might provide in principle. That depends on a multitude of additional factors, two of which bear mentioning here. First is the challenge of carefully orchestrating what is a complex multifaceted air and missile campaign over many days of execution. This depends critically 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 creating a Firepower Coordination Center 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. 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 salvoes of missiles and waves of aircraft operating in multiple sectors. That China could be confident in successfully orchestrating such a complex joint campaign at present seems doubtful.

The second factor is a less obvious but nonetheless essential element to successful use of cruise missiles in warfare: the optimization of missiles to achieve their desired mission objective. 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 global positioning technologies. To be sure, the advent of global positioning technology has eased the process somewhat, and sheer volume of fires can compensate for accuracy limitations to some extent. But the process of becoming truly proficient requires more than simple access to technology. To learn from their successes and errors requires that missile developers have not only the kind of sophisticated diagnostic equipment that provides hints about system performance but also highly skilled systems integration specialists who possess specialized know-how accumulated over years of interaction with other skilled missile developers.

Notes

Portions of this chapter draw on Dennis M. Gormley, Andrew S. Erickson, and Jingdong Yuan, *Chinese Cruise Missiles: A Quiet Force-Multiplier*, *China Security Perspective*, vol. 10 (Washington, DC: National Defense University, Institute for National Strategic Studies, 2011). The authors thank Jasper Liao for his research assistance, Dennis Gormley for reviewing the manuscript, and Phillip Saunders for numerous useful insights.

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China's aircraft carrier program is already making major waves well before the first ship has even been completed. Undoubtedly, this development heralds a new era in Chinese national security policy. While *Chinese Aerospace Power* presents substantial new insight on that particular question, its main focus is decidedly broader in scope. This book offers a comprehensive survey of Chinese aerospace developments, concentrating on areas of potential strategic significance previously unexplored in Western scholarship. It also links these developments to the vast maritime battlespace of the Asia-Pacific region and highlights the consequent implications for the U.S. military, particularly the U.S. Navy.

The possibility of a future Chinese expeditionary force operating off Africa under the protective umbrella of carrier aircraft is not without consequence for the global strategic balance. However, a simpler set of aerospace systems, from microsatellites to unmanned aerial vehicles to ballistic and cruise missiles, is already challenging U.S. maritime dominance in East Asia. Cumulatively, progress in all major aerospace dimensions by various elements of the People's Liberation Army Navy (PLAN) signifies a new period in which Chinese forces are now decidedly altering the complexion of the military balance in the East Asian littoral.

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issues, simultaneously evaluating the Chinese aerospace challenge and its implications for U.S. naval strategy.

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Foreword

IT HAS BEEN MORE than thirty years since the United States established formal diplomatic relations with the People's Republic of China (PRC), yet those relations remain ambiguous and perplexing. The U.S. government seeks to encourage the PRC's evolution into a responsible stakeholder on the world stage, especially in the Pacific, while the Department of Defense strives to balance military-to-military interaction with the PLA and yet still maintain credible deterrence against China's rapidly increasing military capability.

The chapters that follow address the reality of the emergence of the People's Liberation Army (and People's Liberation Army Navy) as a modern, complex military. They are not intended to assuage either hawks or doves on the controversial issue of China; rather, they provide a broad and objective assessment of Chinese aerospace and maritime power by professional researchers who take their analyses with the utmost seriousness. This is important work.

Is war with China possible? Regrettably, yes. Acknowledging that unfortunate fact and ensuring that the United States is sufficiently prepared to prevent and deter such a conflict is what this volume is about. The most essential work being done today is the broad effort to avoid conflict with the PRC without compromising our national principles. Global economic challenges are daunting, but the threat of a nuclear-enabled Iran and North Korea, or terrorists with weapons of mass destruction, pale in comparison to the potential devastation that might occur if war erupts between the United States and China. Beyond imperiling the survival of Taiwan, war with China would cause broader physical and economic destruction and could very well spiral into a lengthy global conflict.

The surest way to limit that potential is to mature the relationship between the United States and China, which is currently stuck in the molasses of its modern origins. It is an elaborate ballet of protocol and protest, pirouetting around the status of Taiwan. We must find a way beyond the false formalities of our special relationship with the PRC. To build on the hopeful signs of the first year of the Ma Ying-jeou government and PRC–Taiwan interaction, I suggest the following: the United States government should stress at every turn that U.S. involvement with Taiwan is good for the PRC. During the government of Chen Shui-bian, U.S. pressure on Chen was key to keeping his actions away from PRC red lines. My experience in dealing with Beijing suggests that a candid and direct approach to diplomacy can yield practical solutions to the delicate problems in U.S.–China relations.

Most fundamentally, we should assess PRC military modernization in objective terms for what we know it is—a significant build up in capability well beyond defensive requirements. Special attention needs to be focused on China's undersea capabilities and also its new prowess in the domain of electronic warfare. Moreover, it is crucial that we avoid the presumption that we can know Beijing's intent. We do not know, and we cannot. We must assess the quality of China's hand without trying to predict how Beijing will ultimately play its cards. We are duty bound to continuously evaluate the military balance, considerations of readiness and risk, and the potential for engagement and deterrence.

Those who ignore the lessons of history may be condemned to repeat it, but those who turn a blind eye to the realities of the present, for example by underestimating China's dramatically enhanced aerospace and maritime power, are assuming irresponsible risks for our nation.

LIEUTENANT GENERAL DANIEL P. LEAF, USAF (RET.)

Lyle J. Goldstein

Introduction

CHINA'S AIRCRAFT CARRIER program is making major waves well before the first ship is completed. Undoubtedly, this development heralds a new era in Chinese national security policy. While the present volume presents substantial new insights on that particular question, its focus is decidedly broader in scope. This book instead aspires to offer a comprehensive survey of Chinese aerospace developments, with a focus particularly on areas of potential strategic significance previously unexplored in Western scholarship. It then seeks to link these developments to the vast maritime battle space of the Asia-Pacific region and consequent implications for the U.S. military, particularly the Navy.

Whether some hypothetical future Chinese expeditionary force operating off Africa a decade or two from now does so under the protective umbrella of carrier aircraft is not without consequence for the global strategic balance. But a relatively simpler set of aerospace systems, from microsatellites to unmanned aerial vehicles to ballistic and cruise missiles, are challenging U.S. maritime dominance in East Asia today. Cumulatively, progress in all major aerospace dimensions by various elements of the People's Liberation Army (PLA) heralds a new period in which Chinese forces are now decidedly altering the complexion of the military balance in the East Asian littoral.

Faced with such rapid developments in Chinese aerospace development, the U.S. Naval War College's China Maritime Studies Institute (CMSI) assembled a group of technical specialists—U.S. Air Force (USAF) and U.S.

Navy operators, and regional experts on—10–11 December 2008 for its fourth annual conference, "Evolving Maritime Roles for Chinese Aerospace Power." Most of the chapters herein were presented initially as papers at that conference, and were subsequently revised substantially to address recent events. A select group of chapters was added to take advantage of the authors' cutting-edge knowledge of key subject areas. The chapters are designed to offer a wide range of perspectives because constructive academic dialogue and debate is at the heart of CMSI's analytical philosophy. They may be read sequentially or individually, depending on the reader's interest.

CMSI is the first undertaking of its kind outside of China. Established in 2006 to increase knowledge and understanding of the maritime dimensions of China's rise, it supports the research needs of the U.S. Navy. Based at the Naval War College in Newport, Rhode Island, CMSI is located at the nexus of academic, policy, and operational communities. In addition to an annual conference and regular research seminars at the college, the institute focuses on intensive research into China's future maritime development, based principally on the ever-growing array of Chinese-language primary sources.

CMSI has developed a record of discussing and analyzing in depth the most advanced areas of Chinese naval development; CMSI's 2005 conference, for example, discussed "China's Future Nuclear Submarine Force." The institute has also been at the forefront of developing a positive working relationship between the U.S. and Chinese navies, hosting in 2007 a conference on "Defining a Maritime Partnership with China." At every step, CMSI has striven to add objectivity and data-based analysis to inform the U.S. Navy's approach to China. In that spirit, this volume, like its four predecessors, contains many chapters that draw extensively on original Chinese-language sources, many not previously cited outside China. Numerous articles and books have been written on Chinese aerospace development, and many more discuss future U.S. naval strategy in the Asia-Pacific region. But no other volume connects the two issues, simultaneously evaluating the Chinese aerospace challenge and its implications for U.S. naval strategy.

This volume is divided into six thematic sections. The first section establishes the maritime context for China's rapid aerospace development. Andrew S. Erickson leads off with a survey of current developments and concludes that "Chinese aerospace capabilities are improving in a rapid, broad-based fashion that can properly be described as a 'revolution.'" Mark A. Stokes and Ian Easton follow with an in-depth analysis of both the organizational underpinnings of China's aerospace development and its regional implications. They find that, "largely driven by a Taiwan scenario, mainland China's capacity to conduct a successful aerospace campaign to swiftly gain a decisive air advantage is surpassing defenses that its neighbors, including Taiwan, Japan, perhaps India, and even U.S. forces operating in the Western Pacific, can field." Wayne A. Ulman reveals that "all indicators point to the continued improvement of both the PLAAF and PLA naval aviation over the next decade, to the point where China will have one of the world's foremost air forces by 2020." Kevin Pollpeter concludes the section by exploring Chinese writings that reveal "an ambitious plan to fully integrate space into Chinese warfighting," with an understanding that this approach could "hold an [adversary's] economy hostage and . . . undermine an opponent's will."

The second section surveys the roles for Chinese aerospace assets in promoting Chinese intelligence, surveillance, and reconnaissance (ISR) and in denying these capabilities to China's potential adversaries in conflict, as well as corresponding maritime implications. Anthony J. Mastalir surveys China's space development, including especially its 11 January 2007 antisatellite (ASAT) test, and concludes that if Beijing's approach in this sensitive domain is not to become the twenty-first century equivalent of the destabilizing German dreadnoughts, then Washington requires a more comprehensive approach to space policy regarding China. Peter A. Dutton discusses China's new initiative to restrict military operations in the airspace over its exclusive economic zone (EEZ), concluding that such efforts must be strongly contested because "information is inherently stabilizing," so that such operations are actually very much in China's own national interest. Richard D. Fisher Jr.'s analysis reveals yet another Chinese ISR capability, noting that "the PLA has apparently committed to investing in a world-class unmanned [aerial vehicle] systems capability," as suggested by the more than twenty-five prototypes or major projects that were unveiled at China's 2010 Zhuhai Airshow. Garth Hekler's extensive research in Chinese sources reveals a similarly robust Chinese effort in the areas of both defensive and offensive airborne electronic warfare—another key element of the evolving ISR environment along the East Asian littoral.

The third section considers prospective maritime missions that might develop further in the future as the result of advances in Chinese aerospace. Dennis J. Blasko investigates helicopter development in the PLA and finds that this process is "still in the rudimentary phase" though the "force is expanding in size and scope of its missions." Lyle J. Goldstein, Miguel Martinez, and William S. Murray address a related theme, Chinese airborne antisubmarine warfare (ASW), and likewise conclude that Chinese capabilities are not robust—with the caveat that China's navy seems to be prioritizing airborne ASW given the amount of ongoing research in this area evident in Chinese sources. Similar limitations are evident in the development of China's aerial refueling capabilities, according to the chapter by Gabriel Collins, Michael McGauvran, and Timothy White, who conclude that "even major AR [aerial refueling] improvements over the next ten to fifteen years will not give the PLA a capacity resembling the global power projection capability the United States has with its more than four hundred tankers." Nan Li and Christopher Weuve take up the issue of Chinese aircraft carrier development. Noting the possible options that Beijing might pursue, they determine that various necessary conditions appear to have been met, including endorsement by the central leadership, affordability, a concise naval strategy incorporating the new platforms, and the availability of the requisite technologies. Daniel J. Kostecka surveys the potential spectrum of Chinese deck aviation development. He concludes that "between now and 2020, the acquisition of aircraft carriers will afford the PLAN the capacity to conduct force projection operations in East Asia."

Section four of this volume examines the emerging threat from Chinese prowess in fielding advanced cruise missiles. Roger Cliff begins by surveying the latest developments in capabilities, doctrine, and missions for China's air forces. He finds that "China's air forces have made substantial strides over the past decade" and "have the potential to present a significant obstacle to U.S. success in such a conflict." Kevin Lanzit and David Chen evaluate the maritime strike mission among China's air forces and note that China already has 570 strike aircraft, which are armed with lethal antiship cruise missiles and capable of operating 1,200 km or more from China's coast. Andrew S. Erickson and Jingdong Yuan describe these missiles in detail, observing that China is no longer reliant on Russia to deploy these advanced weapons. Michael S. Chase focuses on the latest dimension of the cruise missile threat, arguing that major progress in Chinese land-attack cruise missiles could allow Beijing "to at least partially address the asymmetry in conventional strategic warfare capabilities that currently prevents the PLA from retaliating in kind if the United States launches conventional attacks against targets on the Chinese mainland."

First among Chinese antiaccess/area denial systems in potential strategic significance is China's DF-21D antiship ballistic missile (ASBM), which Admiral Robert Willard, commander, U.S. Pacific Command, declared in December 2010 to have reached the equivalent of initial operational capability.[1] The vital issue of Chinese ASBM development is addressed in section five of the present volume. Ron Christman describes the conventional force of the PLA Second Artillery Corps as seven times larger than the nuclear forces component of the service. Andrew S. Erickson and David D. Yang probe the writings of Chinese analysts concerning China's emerging ASBM capability and conclude that this concept has a long and well-developed history in Chinese strategic thought. Toshi Yoshihara examines Chinese perspectives on the ballistic missile defense architecture and finds that China views Aegis missile defense systems as a highly lucrative target for striking U.S. Navy carrier strike groups (CSGs) in a conflict scenario. Paul S. Giarra then evaluates the implications of Chinese ASBM development for the U.S. Navy and comes to the stark conclusion that the deployment of an effective ASBM by China could alter naval warfare to an extraordinary extent, comparable to the introduction of aircraft and submarines in the twentieth century.

Concluding chapters in section six develop more comprehensive assessments. Eric Hagt develops the sobering assessment that "time (and money) appears to be on China's side. Although the United States will remain the dominant military power at the global scale for decades to come, in the regional context of Taiwan, China's near seas, or even within the second island chain, the demands for power projection are far less onerous for China." James R. Holmes posits that "since the dawn of carrier warfare, U.S. naval strategy has viewed command of the air as a prerequisite for surface fleet operations" and asserts that this assumption is increasingly questionable regarding any possible conflict in the East Asian littoral. Larry M. Wortzel judges that the "U.S. Navy and Air Force . . . will likely be hindered in carrying out some . . . missions in the Western Pacific, particularly within proximity of China." Xiaoming Zhang and Sean D. McClung argue that much improvement is needed in U.S. studies of Chinese air and space power, which is "being transformed." They demonstrate that the PLAAF faces challenges both in upgrading its own forces and in competing with the General Armament Department and the Second Artillery Corps for ownership of space-based platforms: "Given the PLAAF's limited ownership and control of space assets, Chinese military theorists have recommended that the service concentrate on building facilitie s and institutions to receive satellite services for communication, weather, navigation, and global positioning." Jeff Hagen evaluates the implications of China's growing aerospace capabilities on U.S. influence in the Asia-Pacific region, and suggests a variety of countermeasures, including "increas[ing] the number of air bases and their hardness; solidify[ing] regional basing arrangements; improv[ing] long-range strike capability; increas[ing] operational coordination between the U.S. Air Force and U.S. Navy; continu[ing] modernization of [the] fighter force; [and,] to the greatest extent possible, encourag[ing] Taiwan and other partners to pursue defensive systems that are more survivable and effective against attack." In his concluding chapter, Eric A. McVadon carefully weighs the motivations behind, and implications of, Beijing's aerospace development.

While he is careful to note the substantial areas in which the United States and China share interests and may build on them further, he also emphasizes that the U.S. Navy and fellow services should make substantial, "innovative" preparations to ensure that their forces do not become outmoded. For instance, "the pending development of maritime UAVs such as the land-based broad-area maritime surveillance (BAMS) UAV- and carrier-based unmanned combat air system (UCAS)" can ameliorate the risk to the CSG or other units posed by the MaRVed MRBMs under development by China.

For now, it is hardly controversial to conclude that revolutionary change is under way in the skies above the East Asian littoral. China's space technology prowess, as demonstrated by its 2007 ASAT test and suggested by rapid progress in microsatellite development, poses a major challenge to heavy U.S. reliance on space capabilities. China's growing inventory of strike aircraft is complemented by newly advanced weaponry and ISR capabilities to support those aircraft. The breadth of this effort is demonstrated by Beijing's efforts in the legal arena to establish greater control of the airspace in its EEZ. The potential deployment of ASBMs is most troubling, however, since this weapon has the potential to render surface forces in the region all but obsolete in a single stroke.

At the same time, this balanced assessment acknowledges that certain real limitations continue to hinder China's aspirations in the aerospace domain, especially as they pertain to the maritime strategic balance. For example, Chinese aircraft have to date lacked reliable, indigenously built jet engines. Moreover, it should be noted that certain Chinese advances in aerospace technologies, processes, and systems (e.g., aerial refueling, as it gradually advances; and increasing reliance on such space-based assets as the emerging Compass satellite navigation-positioning system) may also open up new vulnerabilities to adversary countermeasures. Most fundamentally, the point is made by many contributors that China's naval air arm, like Chinese aviation in general, remains the "poor cousin" of Chinese aerospace, and progress has been moderate or even slow in developing key areas (e.g., doctrine for integrated aerospace operations in the maritime domain).

A key finding of this volume and also the December 2008 conference is that the U.S. armed forces as a whole must come to grips with enhanced Chinese long-range precision-strike capabilities that are now coming to fruition and that pose a significant threat to forces in the Western Pacific theater. The development of such capabilities as the ASBM strongly suggest that America's future fleet must reduce its vulnerability to long-range strike, with an emphasis on undersea capabilities as well as unmanned systems in order to preserve survivability in a more challenging threat environment. Additionally, evolving Chinese aerospace capabilities raise the salience of deterrence initiatives as well as the imperative to develop effective crisis-management mechanisms, not to mention a robust, long-term cooperative engagement strategy. Although American and Chinese aspirations for the twenty-first century are not so different, creativity and determination are nevertheless required to find ways to cooperate in meaningful ways on the seas and in the air and space above them. Indeed, many at the 2008 conference suggested that enhanced military-to-military engagement could reduce the mistrust that might fuel arms racing in the aerospace dimension.

The editors of this volume wish to thank, above all, the researchers who have contributed to it. Here it must be emphasized that all opinions expressed in this book are those of the authors and editors alone and in no way represent the policies or estimates of the U.S. Navy or any other organization of the U.S. government. We also are tremendously grateful to those who helped to organize the December 2008 conference, including especially Dalton Alexander, Leah Averitt, Gigi Davis, Julia Gage, Christina Hartley, Albert Lawton, Jim Lewis, Debbie Maddix, Brian Pagel, and Michael Sherlock. CMSI wishes to thank Raytheon Integrated Defense Systems for its support of the conference through a generous gift to the Naval War College Foundation. Timely and thorough assistance from key members of the Naval War College's Information Resources Department, including Mike Carroll, Neil Davis, Luke Desrochers, Dave Fields, Kerrie Hull, John Neves, and Rodham Smith, was essential to enabling Andrew S. Erickson to edit the manuscript from Seoul, South Korea; as were facilities generously provided there by Major Christopher M. Heber, USAF, and Major Cheree S. Kochen, USAF. The support of Naval War College leadership has been critical to the success of CMSI and in enabling the creation of research products such as the present volume. Finally, we wish to thank Naval Institute Press for its professionalism and dedication in publication of the series "Studies in Chinese Maritime Development," of which this is the fifth volume.

Notes

1. Andrew S. Erickson, "China's Anti-Ship Ballistic Missile (ASBM) Reaches Equivalent of 'Initial Operational Capability' (IOC)—Where It's Going and What it Means," *China Analysis from Original Sources*, 4 January 2011, http://www.andrewerickson.com/2011/01/china%E2%80%99s-anti-ship-ballistic-missile-asbm-reaches-equivalent-of-%E2%80%9Cinitial-operational-capability%E2%80%9D-ioc%E2%80%94where-it%E2%80%99s-going-and-what-it-means/.