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ADVANCED TECHNOLOGY ACQUISITION STRATEGIES

OF THE PEOPLE'S REPUBLIC OF CHINA

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Acronyms

ABM	anti-ballistic missile
AEW	airborne early warning
AMRAAM	Advanced Medium-range Air-to-Air Missile
ASAT	anti-satellite
ASCM	anti-ship cruise missile
ASW	anti-submarine warfare
AVIC-II	Aviation Industries of China II
AWACS	airborne warning and control system
BIS	Bureau of Industry and Security
C4ISR	command, control, communications, computers, intelligence, surveillance & reconnaissance
CAEP	China Academy of Engineering Physics
CFIUS	Committee on Foreign Investment in the United States
CIA	Central Intelligence Agency
CCP	Chinese Communist Party
CMC	Central Military Commission
COSTIND	Commission of Science, Technology, and Industry for National Defense
DIA	Defense Intelligence Agency
DoD	U.S. Department of Defense
DOE	Department of Energy
DSTC	Defense Science and Technology Commission
ESA	electronically steered phased-array
FBI	Federal Bureau of Investigation
FBIS	Foreign Broadcast Information Service
FEL	free electron laser
FOBS	Fractional Orbital Bombardment System
GAD	General Armaments Department
GAO	Government Accountability Office
GDP	gross domestic product

GERD	gross domestic expenditure on R&D
GLD	General Logistics Department
GSD	General Staff Department
HARP	High Altitude Research Program
IAPCM	Institute of Applied Physics and Computational Mathematics
ICBM	inter-continental ballistic missile
IOE	Institute of Optics and Electronics
IRC	Independent Review Committee
ISI	Inter-Services Intelligence
KKV	kinetic kill vehicle
LACM	land attack cruise missile
MID/PLA	Military Intelligence Department of the People's Liberation Army
MSS	Ministry of State Security
NAIC	National Air Intelligence Center
NCIX	National Counterintelligence Executive
NIBS	National Institute for Biological Sciences
NITKA	Ukrainian Research Test and Flying Training Center
NRO	National Reconnaissance Office
OTH	over-the-horizon
PACOM	United States Pacific Command
PFIAB	President's Foreign Intelligence Advisory Board
PLA	People's Liberation Army
PLAAF	People's Liberation Army Air Force
PLAN	People's Liberation Army Navy
PPP	purchasing power parity
PRC	People's Republic of China
QED	quiet electric drive
R&D	research and development
S&T	science and technology
SAM	surface-to-air missile
SCO	Shanghai Cooperation Organization

SCOSTIND	State Commission of Science, Technology and Industry for National Defense
SDI	Strategic Defense Initiative
SLV	space launch vehicle
SPIE	International Society for Optics and Photonics
SSTC	State Science and Technology Commission
TBM	theater ballistic missile
THAAD	Terminal High Altitude Area Defense
TLAM	Tomahawk Land Attack Missile
UAV	unmanned aerial vehicle

EXECUTIVE SUMMARY

Central to the Chinese explanation for China's present-day subordination to the West is the nation's historical technological inferiority. China's defeats in the Opium Wars of the 19th century, which the Chinese consider to have inaugurated a "century of national humiliation," are commonly attributed to the poor quality of its military technology. More recent episodes have reinforced the perception of China's technological backwardness relative to the Western powers. Among these are the 1991 Persian Gulf War and the 1999 bombing of China's embassy in Belgrade by U.S. aircraft. Consequently, the decades-long effort of the People's Republic of China (PRC) to achieve strategic parity with the West has focused heavily on acquiring advanced military technology.

Two characteristics of China's military modernization effort stand out. The first concerns the transformation of the People's Liberation Army (PLA) from a predominantly ground force oriented toward waging a "people's war" in the Chinese interior to one capable of defending China's periphery and projecting power in the region. The second evolution involves a shift away from reliance on quantitative superiority and toward a force boasting sophisticated aircraft and naval platforms, precision-strike weapons, and modern C4ISR capabilities. Both dimensions of the PLA's modernization depend heavily on investments in China's science and technology (S&T) infrastructure, reform of its defense industry, and procurement of advanced weapons from abroad.

The purpose of this study is to identify a small number of bins into which China's strategies for acquiring advanced technology, and especially military technology, can be assigned. In the context of the study, "acquisition" is broadly interpreted, encompassing a variety of means by which technology comes into PRC possession. It includes external as well as domestic sources of technology, purchases as well as thefts, foreign-assisted developments as well as wholly indigenous achievements, and strictly military-oriented technologies as well as those featuring dual uses. A greater understanding of these strategies promises to provide insights into future Chinese military modernization efforts.

No attempt is made in the study to address the more nuanced question of how China leverages the technologies it acquires. Nor is the study intended to address the deeper motives reflected in China's acquisitions or identify its leaders' "grand strategy" for reaching parity with the most advanced powers. In part, this choice reflects the general difficulty in identifying overarching national strategies, which seldom exist as the lucid, centrally-dictated directives that many analysts imagine. Such analyses often assume a degree of consistent, top-level coordination by policymakers that may be at odds with reality. Instead, China's national objectives are generally pursued in ways that reflect the historical and bureaucratic circumstances of the moment. It follows that any assessment of China's strategies for acquiring advanced technology must be careful to avoid definitive conclusions, especially about any single approach.

Report Roadmap & Conclusions in Brief

The report is organized into the following sections, which describe an ensemble of acquisition strategies that China pursues to obtain military-related and dual-use technology.

Section 1: Overt Acquisition of Foreign Weapons and Technology

The first section concerns the purchase of weapon systems and other military capabilities from China's principal arms suppliers, including Russia, Ukraine, the European Union, and Pakistan. The section broadly describes several major systems that China requires for its military modernization effort.

Conclusions in Brief: The PRC continues to rely on foreign technology acquisitions to modernize its national infrastructure, including its armed forces. Over several decades, Chinese leaders have pursued what has been described as a policy of "selective modernization" in which China acquires technologies from abroad to meet certain needs in the short- to medium-term while continuing to develop an indigenous research and development (R&D) and production infrastructure over the long term. This strategy represents a cost-effective method of achieving rapid modernization. Over time, China appears intent on eschewing procurement of foreign weapons as its own technological capacity matures.

Section 2: Unsanctioned Alliances

This section describes the military relationship that exists between the PRC and the State of Israel. Second only to Russia as a source of China's advanced military technology, Israel has been one of China's most strategically important partners.

Conclusions in Brief: Many U.S. analysts have suggested that the Sino-Israeli partnership offers China a "back door" to Western military technology. However, the present status of the relationship is unclear following several highly public disagreements in the 2000s between Israel and the United States over the former's arms dealings with China.

Section 3: Illicit Technology Acquisitions

This section explores the PRC's use of espionage and other clandestine means to acquire military and dual-use technology from the world's most advanced countries. In particular, it addresses China's reliance on non-professional intelligence gatherers to acquire technology, as well as its "ethnic targeting" of Chinese Americans.

Conclusions in Brief: One distinctive feature of China's illicit technology acquisition is the autonomy given to research institutes, corporations, and other entities to devise collection schemes according to their particular needs. Another is China's emphasis on "actuarial" intelligence, or the aggregation of small amounts of information from a wide variety of sources. Targeting ethnic Chinese in the United States is also a prevalent tactic of the PRC's intelligence agencies; however, several high-profile espionage cases have drawn attention to this practice. While these cases may have resulted in a decreased reliance on ethnic Chinese, the open literature offers no insight into China's operational responses to these cases.

Section 4: Reverse-Engineering

This section examines the Chinese practice of obtaining weapons and technology prototypes, dissecting them, and attempting to replicate them. It includes several historical examples of Chinese reverse-engineering and explores the efficacy of cloning advanced military technologies in the modern era.

Conclusions in Brief: A certain mythology surrounds China's use of reverse-engineering that may lead to its overemphasis in Western analyses. Some experts are skeptical that the practice remains feasible given the increasing dependence of advanced weapons on software. Others argue that the effort offers only temporary parity with sophisticated adversaries, whose continuing development of new capabilities presents a constantly moving target. Finally, reliance on reverse-engineering comes at the expense of building up China's long-term capacity for indigenous innovation. These drawbacks call into question the extent to which the PRC will continue to rely on reverse-engineering to acquire advanced technology.

Section 5: Indigenous Research and Development

This section discusses the indigenous content of China's advanced military capabilities and the extent to which the PLA's modernization will rely on domestic S&T achievements. It discusses early Chinese technology development initiatives such as the 863 Program as well as the influence of less structured sources of scientific talent, including foreign-educated Chinese.

Conclusions in Brief: While China's scientists have produced a number of impressive achievements, for decades Chinese technological accomplishment did not extend far beyond the realm of strategic weapons. The drive toward more fulsome S&T achievements was accelerated by the launch of the 863 Program in the mid-1980s. Despite substantial progress since then, China's development of indigenous technology remains far from world-class in most domains. Chinese R&D continues to rely on Western innovations. Its defense-industrial capacity suffers from a number of structural deficiencies, including a lack of competition among major weapons producers. The PRC has sought to improve the S&T environment in part by cultivating scientific talent at home and enticing foreign-educated Chinese to return to China.

Section 6: Acquisition and Development of Dual-Use Technology

This section addresses China's efforts to harness dual-use technologies, often developed or acquired through its commercial sector, for use in PLA weapons. The principal sources of these technologies are foreign purchases, acquisition of Western companies, and technology transfers as part of commercial activities. This section includes examples of China's dual-use technology acquisition.

Conclusions in Brief: Western industry has been a key source of China's dual-use technology, including computers, software, semiconductors, and integrated circuits. An increasingly common Chinese method of acquiring dual-use technology is to enter into commercial arrangements with foreign corporations that explicitly require technology-sharing, which Chinese representatives emphasize in negotiations. This behavior has been observed in the space launch sector, where China sought technology that, in addition to aiding its commercial space industry, could improve the performance of ballistic missiles. Additionally, China is thought to pursue certain military technologies that can benefit its civilian high-tech infrastructure. This approach positions China to maximize its return on investment, benefiting both its military and national economy. Further, developing military capabilities through the exploitation of dual-use technologies may allow China to increase its strength in a way that appears less threatening to the United States and its neighbors. Finally, mastering a diverse range of technologies delivers to China the status of being a truly advanced nation rather than one capable of achievements in only a limited set of fields.

Section 7: Case Studies in Technology Acquisition

The final section features four case studies of strategic military capabilities that China has pursued. These examples illustrate how a variety of technology acquisition strategies may be synthesized to achieve a particular capability.

- **Case Study 1: Land Attack Cruise Missiles (LACMs).** The first case study discusses China's development of conventionally armed LACMs. It includes an overview of the LACM's constituent technologies and then shifts to the various strategies China has employed to acquire these technologies. Finally, it discusses China's espionage efforts in support of its cruise missile program, as well as its illicit acquisition of U.S. and Russian cruise missiles for the purpose of reverse-engineering.
- **Case Study 2: Hit-to-Kill Technology.** The second case study concerns the technology that underlies China's pursuit of ASAT and ABM capabilities—so-called "hit-to-kill" or kinetic kill vehicles. The study discusses the technologies that must be integrated to achieve hit-to-kill. Additionally, it provides an overview of China's strategies to acquire the necessary technology, including reliance on foreign missile technology and indigenous development of components.
- **Case Study 3: Adaptive Optics for High Energy Laser Applications.** The third case study provides an example of the link between PRC investments in its civilian S&T infrastructure and the development of military capabilities. Specifically, it explores China's pursuit of high-powered lasers, particularly adaptive optics, which allow these beams to be focused through the atmosphere to perform missions such as tracking, dazzling, and possibly blinding adversary reconnaissance satellites.
- **Case Study 4: China's Acquisition of Strategic Weapons.** The final case study reviews the evolution of China's acquisition of nuclear weapons, ballistic missiles, and ballistic-missile submarines. Special attention is given to the development of S&T planning organizations that are responsible for the acquisition of strategic forces.

INTRODUCTION

Among the historical narratives that influence the modern-day Chinese worldview, few are more potent or durable than the perception of China's past humiliation at the hands of the West. According to this narrative, China's defeat by Britain and France in the Opium Wars of the 19th century inaugurated a "century of national humiliation" (*bǎinián guóchǐ*) that began to ebb only with the founding of the People's Republic of China (PRC) in 1949.[1] The influence of this bitter historical experience on the outlook of contemporary Chinese can scarcely be overstated. Many see its legacy in China's present-day neuralgia regarding Western "interference" in China's "internal affairs"—that is, the resolution of Taiwan's status. The notion of correcting the historical anomaly of China's subordination to the West animates much of Chinese strategic thinking today.

Central to the Chinese explanation for this phenomenon has been the nation's technological inferiority, particularly with respect to military technology. This circumstance is all the more galling in light of China's self-image as a culture of once unparalleled scientific preeminence. Through much of its history, particularly during the Song Dynasty (960-1279), China had been a world leader in technological innovation. Its achievements often surpassed the European powers in mathematics, astronomy, manufacturing, and many other facets of economic and cultural development. The "four great inventions" (*sì dà fā míng*) of ancient China—the compass, gunpowder, papermaking, and printing—remain sources of national pride today, as do the expeditions of Ming Dynasty (1368-1644) mariner Zheng He, who led seven voyages to South Asia and East Africa between 1405 and 1433. Zheng's giant junks, described as "far larger, more numerous and technologically advanced than the caravels of his contemporary Spanish and Portuguese explorers," continue to fascinate historians today.[2]

Yet by the mid-19th century, a technologically stagnant China was nearing the nadir of a long and steep decline, falling far behind the European powers. From the start of the First Opium War in 1839, British gunboats with heavy cannon and soldiers with modern muskets easily bested the numerically superior Chinese. Humiliating terms were imposed on a demoralized Qing Dynasty, including the cession of Hong Kong. Further insults followed at the hands of China's neighbors. The loss to Japan in the Sino-Japanese War in 1895 cost the Chinese control of Korea and Taiwan. A decade later, during the Russo-Japanese War, China experienced the indignity of witnessing two foreign armies fight over control of the Chinese territory of Manchuria.[3]

References to this historical period figure prominently in contemporary Chinese military writings, which are often thick with the language of national humiliation. In a recent analysis of the PRC's need for a "blue water" navy, for example, strategist Guo Yadong describes the Chinese nation as having "suffered

[1] Orville Schell, "China: Humiliation & the Olympics," *New York Review of Books*, Volume 55, Number 13, August 14, 2008: http://www.nybooks.com/articles/21715. During Mao Zedong's speech announcing the establishment of the PRC, he declared, "Ours will no longer be a nation subject to insult and humiliation. We have stood up." See "Opening Address by Mao Zedong, Chairman of the Chinese Communist Party, at the First Plenary Session of the Chinese People's Political Consultative Conference," September 21, 1949: http://www.international.ucla.edu/eas/documents/mao490921.htm

[2] "The People's Liberation Army Navy: A Modern Navy with Chinese Characteristics," U.S. Office of Naval Intelligence, August 2009, p. 3, http://www.nmic.navy.mil/Intelligence_Community/docs/china_army_navy.pdf; see also Evan Hadingham, "Ancient Chinese Explorers," PBS NOVA, updated April 2003, http://www.pbs.org/wgbh/nova/sultan/explorers.html

[3] Alison Kaufman, "The 'Century of Humiliation,' Then and Now: Changing Chinese Perceptions Of the International Order," Prepared for the 2009 Annual Meeting of the American Political Science Association, September 3-6, 2009: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1449346

disgrace for almost one hundred years" as a result of invasions by the naval forces of the major powers.[4] These writings constitute what scholar William A. Callahan has described as "a unique feature of Communist Chinese historiography and identity: the very deliberate celebration of a national insecurity."[5] Implicit in these allusions to China's historical slights is the imperative of preventing their recurrence. Indeed, transcending what remains for the Chinese the almost incomprehensible historical accident of China's subordination has arguably been *the* central driver of their race to "catch up" technologically ever since. This motivation, perhaps more than any other, underlies the nation's drive for a powerful, advanced military today.

In the decades after the Opium Wars, China's leaders launched a national "Self-Strengthening Movement" whose chief feature was the adoption of Western technology and martial traditions. In an undertaking that parallels the current modernization drive of the People's Liberation Army (PLA), during the 1860s China began to import European weapons and war-fighting doctrine on a considerable scale. Later, this campaign expanded to include other spheres such as commerce and industry before stalling near the turn of the century.[6] Nevertheless, the emphasis on cultivating Western knowledge endured, and for decades great numbers of young Chinese were dispatched to France, Germany, Great Britain, Japan, and the United States to be educated.

While the period between the Opium Wars and the founding of the PRC looms largest in the Chinese consciousness, more recent military setbacks have imparted similar lessons. Evan Feigenbaum traces China's recognition of the need for advanced military technology to its early experience in the Korean War, during which the PLA "paid perhaps the harshest and most immediate price for China's poverty in modern industry."[7] As Marshal Nie Rongzhen later remarked, "since the Korean war, we have often been disturbed by the point [that] we lagged far behind the then enemy in military technologies."[8] However, these shortcomings persisted a quarter-century later when China waged a brief but costly war with Vietnam. As Russell D. Howard recalls,

> The Chinese were shocked to discover that the traditions of the Long March, World War II and Korea were not enough to meet the Vietnamese, with their modern Soviet (and U.S.) equipment….The PLA lacked adequate communications, transport and logistics and were burdened with an elaborate and archaic command structure. Their maps were 75 years old. Runners were employed to relay orders because there were few radios (and those they had were not secure).[9]

Although these experiences featured little of the national trauma that accompanied the wars of the 19th century, they nonetheless had a sobering effect on China's military leaders. Other episodes reinforced their perception of the PLA's technological backwardness. Among these was the 1991 Persian Gulf War, in which a U.S.-led coalition eviscerated a large but technologically inept Iraqi force. The acceleration of the PLA's modernization over the last two decades, and particularly its emphasis on

[4] Guo Yadong, "China Should Resist Noises of Threat Theories and Stick to Building Deep Blue Navy," *Huanqiu Shibao Online*, May 5, 2010, Open Source Center: CPP20100506710007.
[5] William A. Callahan, "National Insecurities: Humiliation, Salvation, and Chinese Nationalism," *Alternatives*, 29 (2004), 199–218: http://www.humiliationstudies.org/documents/CallahanChina.pdf
[6] Mary Clabaugh Wright, *The Last Stand of Chinese Conservatism: The T'ung-Chih Restoration, 1862-1874*, Stanford University Press: 1957. pp. 196-221.
[7] Evan A. Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age*, Stanford University Press, 2003. p. 16. See also John Wilson Lewis and Xue Litai, *China Builds the Bomb*, Stanford University Press, 1988. p. 9.
[8] Nie Rongzhen, *Nie Rongzhen huiyilu* (Memoirs of Nie Rongzhen), Beijing: Jiefangjun chubanshe, 1984, p. 787. As cited in John Wilson Lewis and Xue Litai, "Strategic Weapons and Chinese Power: The Formative Years," *The China Quarterly*, December 1987.
[9] Russell D. Howard, "The Chinese People's Liberation Army: 'Short Arms and Slow Legs,'" INSS Occasional Paper 28, *Regional Security Series,* September 1999: http://www.fas.org/nuke/guide/china/doctrine/ocp28.htm

information warfare, is often attributed to the deep impression the U.S. performance made on Chinese officers.[10] As strategist Chen Zhou recounts, the Persian Gulf War "helped change the direction of our defense modernization policy, in that it prompted us to devote ourselves to information technology, which is revolutionizing the military sector."[11] This lesson was later enshrined in an objective that appears frequently in official Chinese writings today—configuring the PLA to "win local wars under the conditions of informationalization."[12] Recognizing their own deficiencies in this arena, Chinese decision-makers appear to have reached the same conclusion as Mao Zedong with respect to the great powers' possession of nuclear arms. According to John Wilson Lewis and Xue Litai, this conclusion was: "Whatever they have, we must have."[13]

A series of events in the mid- to late-1990s added further impetus to the PLA's modernization drive. The U.S. deployment of two aircraft carriers off the coast of Taiwan during the PLA's 1996 missile exercises influenced China's effort to develop the means to deny U.S. forces access to the western Pacific in the event of a Taiwan conflict. This crisis also added new urgency to China's military modernization and reform program. Three years later, the U.S.-led intervention in Kosovo validated China's perception of the United States as willing to violate another country's national sovereignty, as well as the correctness of Chinese assessments about the nature of modern warfare. The bombing of China's embassy in Belgrade by U.S. aircraft during this conflict was yet another jarring event. Occurring in the context of yet another dazzling U.S. military display, the incident intensified two already powerful forces underlying China's defense transformation: a sense of technological inferiority and a resolve to prevent further national insults resulting from China's military inadequacy. Centers for defense research and development (R&D) profited from across-the-board increases in the wake of these events.[14]

Along with the influence of foreign military operations, two characteristics of China's military modernization effort stand out. The first concerns the PLA's transformation from a predominantly ground force oriented toward waging a protracted "people's war" (*rén mín zhàn zhēng*) in the Chinese interior to one capable of defending China's periphery and, to a limited extent, projecting power within the region.[15] The focus of this effort is largely to deny enemies freedom of action in the western Pacific, especially in the waters surrounding Taiwan. The second evolution involves a shift away from reliance on quantitative superiority in personnel and materiel and toward a force boasting sophisticated aircraft and naval platforms, precision-strike weapons, and modern C4ISR capabilities.[16] Both dimensions of the PLA's modernization depend heavily on investments in China's science and technology (S&T) infrastructure, reform of its defense industry, and acquisition of advanced weapons and technology from abroad. These efforts began in earnest in the late 1970s and continue to the present day.

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[10] David Shambaugh, "China's Military Views the World: Ambivalent Security," *International Security*, Volume 24, Number 3, Winter 1999/2000: http://www.jstor.org/pss/2539305

[11] Siegesmund von Ilsemann and Andreas Lorenz, "Spiegel Interview with Top Chinese Military Strategist," *Der Spiegel*, March 19, 2008: http://www.spiegel.de/international/world/0,1518,542506,00.html

[12] Information Office of the State Council of the People's Republic of China, "China's National Defense in 2004." http://www.china.org.cn/e-white/20041227/index.htm

[13] John Wilson Lewis and Xue Litai, *China's Strategic Seapower: The Politics of Force Modernization in the Nuclear Age,* Stanford University Press, 1994. p. 209.

[14] Gregory Kulacki and Jeffrey G. Lewis, "Understanding China's Antisatellite Test," *Nonproliferation Review*, Volume 15, Number 2, July 2008: http://cns.miis.edu/npr/152toc.htm

[15] While official writings insist that the PLA still "adheres to the people's war concept and develops the strategies and tactics of the people's war," these statements are more rhetorical than suggestive of actual warfighting doctrine. See Information Office of the State Council of the People's Republic of China, "China's National Defense in 2004," http://www.china.org.cn/e-white/20041227/index.htm

[16] C4ISR: command, control, communications, computers, intelligence, surveillance, and reconnaissance.

For China perhaps more than other emerging powers, the acquisition of advanced technology has long served a dual purpose. Along with their practical uses, technological achievements bestow a certain prestige upon the nation simply for having obtained them. As the late Chinese leader Deng Xiaoping remarked in 1988, the attainment of high technology, and especially advanced military capabilities, is the *sine qua non* for China's membership in the elite club of nations to which it aspires. "If it were not for the atomic bomb, the hydrogen bomb and the satellites we have launched since the 1960s," Deng asserted, "China would not have its present international standing as a great, influential country. These achievements demonstrate a nation's abilities and are a sign of its level of prosperity and development."[17] Evidence of this mentality can be found in the expression Chinese scientists and engineers use to explain China's sizable expenditures on its space program—an investment intended to secure "a place for one's mat," or China's rightful place among space-faring nations.[18] For decades the sentiment behind this expression has proven remarkably enduring among the top echelons of the communist party. In a widely quoted remark, Chinese Premier Wen Jiabao argued in a 2005 speech that "science and technology are the decisive factors in the competition of comprehensive national strength."[19]

Study Purpose

China's development and acquisition of advanced military capabilities has generated a vast literature in which Western scholars have sought to identify the weapons the PRC pursues and its intentions in pursuing them. For more than four decades analysts have sought to assess the strategies China employs to acquire high technology both to enable its military modernization and facilitate its broader national development. For example, a 1975 RAND Corporation analysis titled *China's Approach to Technology Acquisition* examined the methods and processes the PRC has employed to acquire advanced technologies.[20] Relying primarily on Western analyses of this sort, this study attempts to distill the key conclusions of these research undertakings. Its chief purpose is to identify a small number of bins into which China's strategies for acquiring technology, and especially advanced military capabilities, can be assigned. A greater understanding of these procurement strategies will improve analysts' insights into future Chinese acquisition efforts as the PLA continues to modernize.

Almost 30 years ago, political scientist Jonathan Pollack enumerated the five key questions around which most Chinese discussion of military modernization revolves: *what to acquire*, *how much*, *how quickly*, *by what means*, and *for what purposes*? This study principally concerns the fourth question in Pollack's formulation—Chinese strategies for acquiring advanced capabilities—and specifically "the degree of external assistance versus indigenous development, and the additional choice between purchases from abroad as opposed to production at home."[21] In the context of this study, "acquisition" is broadly interpreted, encompassing a variety of means by which technology comes into PRC possession. It includes external as well as domestic sources of technology; purchases of technology as well as thefts; foreign-assisted developments as well as wholly indigenous achievements; and strictly military-oriented

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[17] "China Must Take Its Place in the Field of High Technology," *People's Daily*, October 24, 1988: http://english.cri.cn/1325/2004-8-5/20@138368.htm

[18] See "Beiyue zhaxing: wuqi yanzhi jiasu" (NATO Bombing: Accelerate Weapons R&D), *Zhongguo Hangtian Bao*, May 12, 1999. See also Gregory Kulacki and Jeffrey G. Lewis, "A Place for One's Mat: China's Space Program, 1956–2003," American Academy of Arts and Sciences, The Reconsidering the Rules of Space Project. 2009: http://www.amacad.org/publications/spaceChina.pdf

[19] Michael Pillsbury, "China's Progress in Technological Competitiveness: The Need for a New Assessment," Prepared for the U.S.-China Economic and Security Review Commission, April 21, 2005: http://www.uscc.gov./researchpapers/2005/05_04_21_technological_progress.pdf

[20] Hans Heymann, Jr., *China's Approach to Technology Acquisition: Part III, Summary Observations*, RAND Corporation monograph, 1975: http://www.rand.org/pubs/reports/R1575/

[21] Jonathan D. Pollack, "China's Military Modernization, Policy, and Strategy," RAND Corporation monograph, December 1980: http://www.rand.org/pubs/papers/2008/P6641.pdf

capabilities as well as dual-use technologies. Of course, technology acquisition paints only a partial picture of the PRC's modernization drive. As Richard A. Bitzinger notes, "Beyond the mere *acquisition* of potentially useful technologies…China must also be able to effectively *leverage*—that is, to absorb, assimilate, and exploit—these technologies for military purposes."[22] [Emphasis in original] No attempt is made in this study to address the more nuanced question of how China responds to the challenge of leveraging the technologies it acquires.

The study also addresses, to a much lesser extent, the subject of Pollack's fifth question—which he describes as "the more particular political objectives to be served by acquiring and employing modern arms." Though in many cases, analysts may be able to superimpose a coherent account of a nation's long-term political and military strategies on its defense investments, this study leaves to others the task of determining the deeper motives reflected in China's technology acquisitions. In part, this choice reflects the general difficulty in identifying overarching national designs. Notwithstanding the scholarship devoted to China's "grand strategy" for this or that undertaking, national strategies seldom exist as the lucid, centrally-dictated directives that many analysts describe. Indeed, as the evolution of the 863 Program—a key Chinese initiative to acquire high technology—suggests, national objectives must still be implemented in ways that reflect the personal, historical, and bureaucratic circumstances of the moment.[23]

While there is reason to doubt that grand strategies explain specific decisions, analyses purporting to identify them abound. Their focus ranges from truly national pursuits to narrower spheres such as science and technology, military modernization, and economic development. For example, a 2000 RAND Corporation analysis posited that the PRC's national "grand strategy" consists of three objectives: preserving internal order, defending against external threats, and achieving significant geopolitical influence.[24] A subsequent RAND study outlined Beijing's three-pronged "grand strategy" for improving its defense-industrial capabilities: selective modernization, civil-military integration, and acquisition of advanced technologies from abroad.[25] In yet another example, Taiwanese scholar Yuan-Kang Wang argues that

> China is pursuing a grand strategy that combines elements of internal balancing and external 'soft balancing.' The strategy of internal balancing aims to increase China's relative power through economic development and military modernization…whereas the strategy of external soft balancing is designed to limit or frustrate U.S. policy initiatives deemed detrimental to Chinese interests…[26]

In the realm of military strategy, American analysts appear to have assigned great significance to Deng Xiaoping's "24-Character Strategy," a succinct formula for guiding China's long-term development while concealing its strength: "Observe calmly; secure our position; cope with affairs calmly; hide our

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[22] Richard A. Bitzinger, "Going Places or Running in Place? China's Efforts to Leverage Advanced Technologies for Military Use," in Susan M. Puska, ed., *People's Liberation Army After Next*, Strategic Studies Institute, U.S. Army War College, August 2000: http://www.strategicstudiesinstitute.army.mil/pdffiles/PUB67.pdf

[23] For more detailed descriptions of the 863 Program, see Section 5: Indigenous Research and Development as well as Case Study: Adaptive Optics below.

[24] Michael D. Swaine and Ashley J. Tellis, "Interpreting China's Grand Strategy: Past, Present, and Future," RAND Corporation monograph, 2000: http://www.rand.org/pubs/monograph_reports/MR1121/

[25] Evan S. Medeiros, Roger Cliff, Keith Crane, and James C. Mulvenon, "A New Direction for China's Defense Industry," RAND Corporation monograph, 2005: http://www.rand.org/pubs/monographs/2005/RAND_MG334.pdf

[26] Yuan-Kang Wang, "China's Grand Strategy and U.S. Primacy: Is China Balancing American Power?" The Brookings Institution Center for Northeast Asian Policy Studies, July 2006: http://www.brookings.edu/fp/cnaps/papers/wang2006.pdf

capacities and bide our time; be good at maintaining a low profile; never claim leadership."[27] Deng's principles were first quoted in the 2002 version of the U.S. Department of Defense's (DoD) *Annual Report to Congress: Military Power of the People's Republic of China* and have appeared in each subsequent edition of the report.[28] Yet, explications of China's "grand" strategies often assume a degree of consistent, top-level coordination by Chinese policymakers that may be at odds with reality. Although there is some basis for this assumption—sweeping bureaucratic mobilization *has* been witnessed throughout China's modern history from the Great Leap Forward (*dàyuèjìn*) to the Four Modernizations (*sì gè xiàn dài huà*)—the suggestion that Chinese institutions operate according to detailed blueprints may overstate the degree of central government control. It may also underplay the influence of political and bureaucratic considerations. Furthermore, many scholars appear skeptical of the coherence of China's long-term aspirations. Thomas M. Kane, for example, dismisses the notion of a consistent and carefully laid national strategy, citing the "complexity of China's government, the absence of consensus within that government and historical oscillations in China's diplomatic alignments."[29] Similarly, Mark Stokes describes PLA modernization planning as "complex and opaque," noting that "[a] number of factors, including emerging doctrine, threat perceptions, and bureaucratic politics, influence Chinese strategic planning, indigenous research and development, and acquisition."[30]

Ascertaining a nation's strategic aims, to say nothing of its preferred instruments for achieving them, is challenging even when access to information is unfettered. Chinese efforts at perception management only compound this difficulty.[31] Ashley Tellis, addressing the narrow topic of China's counterspace ambitions, notes that

> [e]ven if one were to mine the entire depth of Chinese literature pertaining to its military and counterspace strategy, no consensus view of its strategic direction would emerge. The extensive debate about German responsibility for the initiation of the First World War, which has been…based entirely on open and transparent access to all manner of primary documents, ought to induce caution about the possibility of reaching clear conclusions about grand strategy, even retrospectively. In the case of China, where the publicly available literature is spotty, controlled, often self-serving and frequently downright deceptive, and actually deals with an evolutionary reality that could be subject to change, even greater caution is in order.[32]

Analysts must therefore be mindful of the limitations in discerning the outputs of a secretive and fluid decision-making process. It follows that any assessment of China's strategies for acquiring advanced technology must be careful to avoid definitive conclusions, especially about any single approach. Accordingly, this study makes no attempt to establish conclusively the preferences of Chinese policymakers in acquiring modern military capabilities. Instead, it describes an ensemble of acquisition strategies to obtain advanced weapons and their underlying technology. These strategies, pursued

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[27] As cited in "Deng Puts Forward New 12-Character Guiding Principle for Internal and Foreign Policies," Ching Pao (Hong Kong), No. 172, pp. 84-86, November 5, 1991. FBIS HK0611100091.

[28] *Annual Report on the Military Power of the People's Republic of China.* Report to Congress Pursuant to the FY2000 National Defense Authorization Act: http://www.defense.gov/news/Jul2002/d20020712china.pdf

[29] Thomas M. Kane, *Chinese Grand Strategy and Maritime Power*, Taylor & Francis: 2002. p. 6.

[30] Mark A. Stokes, *China's Strategic Modernization: Implications for the United States*, U.S. Army War College, Strategic Studies Institute, September 1999: http://www.fas.org/nuke/guide/china/doctrine/chinamod.pdf. p. 7.

[31] Peter Callamari and Derek Reveron, "China's Use of Perception Management," *International Journal of Intelligence and CounterIntelligence*, Volume 16, Issue 1, Spring 2003: http://dx.doi.org/10.1080/713830380. See also Eric C. Anderson and Jeffrey G. Engstrom, "China's Use of Perception Management and Strategic Deception," Report prepared for the U.S.-China Economic and Security Review Commission, November 2009.

[32] Michael Krepon, et al., "China's Military Space Strategy: An Exchange," *Survival*, Volume 50, Number 1, February-March 2008: http://www.carnegieendowment.org/files/SurvivalTellis.pdf

independently or in combination with others, provide broad insight into the PRC's methods for developing a modern, world-class military.

Report Roadmap

The material presented in this report is organized into the following sections, which describe the various strategies the PRC pursues to acquire advanced military and dual-use technology.

- **Section 1: Overt Acquisition of Foreign Weapons and Technology.** The first section concerns the purchase of weapon systems and other military capabilities from China's principal arms suppliers—Russia, Ukraine, various European nations, and, to a lesser extent, Pakistan. Included in this section is the often overlooked military relationship between China and the United States prior to the 1989 Tiananmen Square crackdown. (While Israel is also a major supplier of arms to China, military transactions between the two countries are included in the subsequent section on Unsanctioned Alliances). The first section does not attempt to provide an exhaustive catalogue of arms sales to China. Rather, it broadly describes a number of major systems that China requires for its military modernization effort but has not attempted to produce indigenously.

- **Section 2: Unsanctioned Alliances.** This section describes the cooperative military relationship between the PRC and the State of Israel. The adjective "unsanctioned" reflects the furtive nature of the relationship, which stems from various political sensitivities on the part of both nations. Israel, second only to Russia as a source of China's advanced military technology, is one of China's most strategically important partners. The focus on Israel is not, however, intended to suggest that this is the only "unsanctioned" alliance supporting Chinese acquisition of strategic technology.

- **Section 3: Illicit Technology Acquisitions.** This section explores the PRC's use of espionage and other clandestine means to acquire military and dual-use technology from the world's most advanced countries. In particular, it addresses China's reliance on non-professional intelligence gatherers to acquire technology, including the use of ethnic Chinese residents of the United States. By illustrating the diversity and, in many cases, relative autonomy of China's intelligence gatherers, this section highlights China's unique approach to espionage among the world's major powers.

- **Section 4: Reverse-Engineering.** This section examines the well-documented practice in which Chinese engineers and technicians' obtain prototype weapons and technology, dissect them, and attempt to replicate them for PLA use. While references to China's use of reverse-engineering appear widely in the open-source literature and have some basis in fact, a certain mythology surrounds the practice that may lead to its overemphasis in Western analyses. This section includes a number of confirmed historical examples of Chinese reverse-engineering and explores the efficacy of cloning the advanced military technologies that the PLA covets in the modern era.

- **Section 5: Indigenous Research and Development.** This section discusses the indigenous content of China's advanced military capabilities. While many, if not most, of these capabilities benefit from the incorporation of foreign technology or expertise, their manufacture in PRC factories and laboratories allows them to be designated as indigenous products. The section discusses early Chinese technology development initiatives such as the 863 Program and its successors as well as the influence of less structured sources of scientific talent such as foreign-educated Chinese.

- **Section 6: Acquisition and Development of Dual-Use Technology.** This section addresses China's efforts to harness dual-use technologies, often developed or acquired through its commercial sector, for use in PLA weapons. The principal sources of these technologies are foreign technology purchases, acquisition of Western companies, and cooperative technology transfers as part of commercial activities. This section includes examples of China's dual-use technology acquisition, including the sale of IBM's personal computing division to the Chinese company Lenovo, which some analysts suggested would improve PLA computing capabilities. Other examples include the controversy surrounding Loral Space & Communications and Hughes Electronics Corporation, which were accused of illegally sharing satellite launch technology that some argued could benefit China's ballistic missile program.

- **Section 7: Case Studies in Technology Acquisition.** While a particular system or capability can be achieved by pursuing a single acquisition strategy—for example, purchasing a working weapon or developing a system indigenously—many of the advanced technologies that the PRC seeks are the products of multiple strategies pursued in combination. This section includes four case studies of strategic military capabilities that China has pursued—Land Attack Cruise Missiles; hit-to-kill technology; adaptive optics for high energy laser applications; and strategic weapons, including nuclear weapons, ballistic missiles, and ballistic-missile submarines. These examples illustrate how a variety of acquisition strategies may be synthesized to achieve a particular capability.

Case Study 1: Land Attack Cruise Missiles
Jeffrey G. Lewis

The first case study discusses China's development of conventionally armed LACMs to complement the PLA's short- and medium-range ballistic missiles. The piece begins with an overview of the LACM's constituent technologies, including its propulsion and guidance systems. Its focus then shifts to the various strategies China has employed to acquire these technologies, including the diversion of dual-use machine tools and harnessing foreign expertise. Finally, the case study discusses China's espionage efforts in support of its cruise missile program, as well as its illicit acquisition of U.S. and Russian cruise missiles for the purpose of reverse-engineering.

Case Study 2: Hit-to-Kill Technology
Jeffrey G. Lewis

The second case study concerns the technology that underlies China's pursuit of anti-satellite (ASAT) and anti-ballistic missile (ABM) capabilities—so-called "hit-to-kill" or kinetic kill vehicles (KKVs). These capabilities are being pursued as part of China's effort to develop hit-to-kill systems that are analogous to sophisticated U.S. missile defense interceptors. The study provides a discussion of the various technologies that must be integrated to achieve hit-to-kill, including tracking systems, seekers that rely on visible or infrared energy to locate a target, attitude determination and control systems, and precision thrusters that maneuver the KKV into collision with the target. Additionally, the study provides an overview of China's strategies to acquire the necessary technology, including reliance on foreign missile technology and indigenous development of components.

Case Study 3: Adaptive Optics for High Energy Laser Applications
Jeffrey G. Lewis

The third case study provides an example of the link between PRC investments in its civilian S&T infrastructure and the potential development of military capabilities. Specifically, the study explores China's pursuit of high-powered lasers, and in particular adaptive optics, which allow these beams to be focused through the atmosphere to perform military missions such as tracking, dazzling, and possibly blinding adversary reconnaissance satellites. China's directed energy and adaptive optics programs differ markedly from its cruise missile and hit-to-kill programs. The latter programs have involved specifying and then acquiring key technologies, often from abroad, to achieve a particular military capability. In the former programs, however, these capabilities are largely the products of an indigenous research and development effort grounded in China's civil and commercial sectors. China's adaptive optics program is included in the larger study to illustrate a technology acquisition process that may foreshadow future indigenous Chinese military developments.

Case Study 4: China's Acquisition of Strategic Weapons
Joshua H. Pollack

The final case study reviews the historic pattern and evolution of China's acquisition of nuclear weapons, ballistic missiles, and ballistic-missile submarines. These technologies initially held a privileged role as the main focus of national science and technology plans, designed to assure the fundamental equality of China with the superpowers. Their role began to diminish with the push for defense conversion and growth of the civilian economy, starting in the mid-to-late 1970s. In the present era, as China finally starts to deploy world-class missile forces, its focus on advanced technologies, including conventional weapons applications, appear to have taken precedence over further strategic nuclear developments. Special attention is given to the development of S&T planning organizations responsible for the acquisition of strategic forces.

SECTION 1: OVERT ACQUISITION OF FOREIGN WEAPONS AND TECHNOLOGY

Like every technologically deficient nation that prizes modern innovations, the PRC has relied heavily on foreign technology acquisitions to build its national infrastructure over the past half-century. In no domain is this more evident than the Chinese military establishment, which has depended on foreign weapons and technology to meet all but the most basic of the nation's defense requirements. Among the various pathways to acquire these modern systems, perhaps the most straightforward is the direct purchase of weapons; China imports arms and military technologies from a number of advanced countries. Except for a two-decade interruption, this approach to technology acquisition has been central to the nation's military development since its founding.

Before the 1960 Sino-Soviet split halted technical cooperation between China and the U.S.S.R., China was the recipient of what has been described as "the most comprehensive technology transfer in modern history."[33] This transfer included, among other advanced technologies, ballistic missiles, fighter and bomber aircraft, nuclear power producing technology, and assistance with the design of nuclear weapons. After Soviet aid was discontinued, however, China was forced into an austere period of technological "self-reliance" (*zili gensheng*).[34] Not long after this technology cut-off, China's scientific maturation was further stunted as the result of a self-imposed technological isolation from the world during the Cultural Revolution.[35]

In many spheres of China's national development during the Cultural Revolution, ideological fervor was the enemy of technological progress. One example concerns the development of advanced aircraft. Erik Lin-Greenberg recalls how the "incompatibility of offensive airpower with [Mao Zedong's] doctrine of 'People's War,'" coupled with the cut-off of Soviet technology in 1960, had the effect of hindering the development of strategic airpower by "preventing the acquisition of new technologies and the development of a doctrine of offensive air warfare."[36] Only in the late 1970s and early 1980s did China begin to recover from the loss of Soviet patronage and the far more calamitous injury of the Cultural Revolution. Since then, its modernization effort has continued without interruption.

When the PRC's military modernization began in earnest in the mid-1980s, Chinese leaders made the pragmatic decision to pursue what Bates Gill and Taeho Kim describe as a "two-track" policy in which China would "acquire foreign technologies to address specific needs over the short term, while making a commitment to developing and advancing indigenous R&D and production capacities over the long term."[37] In the context of the PLA's modernization, the timeframe described here as "short term" must be interpreted relatively, for it continues to the present day. While China has made remarkable advances in its indigenous production capacity since the 1980s, the acquisition of foreign weapons technology

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[33] Hans Heymann, Jr., *China's Approach to Technology Acquisition: Part III, Summary Observations*, RAND Corporation monograph, 1975: http://www.rand.org/pubs/reports/R1575/

[34] Evan A. Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age*, Stanford University Press, 2003. p. 39.

[35] Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China's 15-year Science and Technology Plan," *Physics Today*, December 2006: http://www.levininstitute.org/pdf/Physics%20Today-2006.pdf

[36] Erik Lin-Greenberg, "Offensive Airpower with Chinese Characteristics," *Air & Space Power Journal* , Fall 2007: http://www.airpower.maxwell.af.mil/airchronicles/apj/apj07/fal07/greenberg.html

[37] Bates Gill and Taeho Kim, *China's Arms Acquisitions from Abroad: A Quest for "Superb and Secret Weapons,"* New York: Oxford University Press, 1995. p. 35.

remains a critical component of the nation's modernization strategy. As Bernard D. Cole and Paul H.B. Godwin note, in light of deficiencies in China's indigenous research, development, and manufacturing capacity, "the quickest way to embark on acquiring advanced military technologies is foreign procurement."[38] Accordingly, China accounted for an impressive 11 percent of global conventional weapon imports during the period 2004–2008.[39]

Purchases of weapons from abroad are necessary not only to fulfill China's immediate defense requirements but also to provide models that can be studied, incorporated into the PLA, and ultimately replicated domestically. Far from a sign of perpetual backwardness, this strategy represents a cost-effective method of achieving rapid modernization. As RAND Corporation analyst Roger Cliff notes, for a nation in a position of technological inferiority that is trying to modernize quickly, "it makes much more sense to try to acquire technologies that have already been developed abroad rather than to try to reinvent them yourself."[40] Phillip Saunders and Erik Quam describe the Chinese effort to modernize the People's Liberation Army Air Force (PLAAF), an undertaking that mirrors China's approach to achieving other advanced capabilities. In this process, modernization occurs through "procurement of advanced aircraft from Russia, continued domestic efforts to design and produce advanced aircraft, and incorporation of imported engines, avionics, and munitions into Chinese aircraft designs."[41] Over time, China's strategy aims to eschew procurement of aviation technology from abroad as its own mastery of advanced aircraft manufacture reaches maturity.

Additionally, some Chinese military capabilities can be classified as neither wholly the result of foreign acquisition or indigenous development. Rather, hybrid undertakings, in which China's scientists capitalize on imported technology and expertise, have grown increasingly common.[42] One example is China's development of an indigenous airborne warning and control system (AWACS), the KJ-2000. Following an aborted deal with Israel and Russia in 2000, in which China would be supplied with the Israeli Aircraft Industries' Phalcon airborne early warning (AEW) radar incorporated with Russian Beriev A-50 Mainstay aircraft, China embarked on a domestic development program in 2004 to produce an AWACS capability.[43] Four aircraft were ultimately produced under the program—one that utilizes an A-50 airframe and three based on modified Russian IL-76 transports already in service with the PLAAF.[44]

The following section briefly describes the major foreign sources of China's advanced weapons systems and military technology. It includes a number of specific examples of arms that the PLA has acquired and the strategic purposes underlying their acquisition. However, the section provides only a limited

[38] Bernard D. Cole and Paul H.B. Godwin, "Advanced Military Technologies and the PLA: Priorities and Capabilities in the 21st Century," in Larry M. Wortzel, ed., *The Chinese Armed Forces in the 21st Century*, Strategic Studies Institute, U.S. Army War College, December 1999: http://www.au.af.mil/au/awc/awcgate/ssi/chin21cent.pdf

[39] Mark Bromley, Paul Holtom, Pieter D. Wezeman, and Siemon T. Wezeman, "SIPRI Arms Transfers Data, 2008," Stockholm International Peace Research Institute Fact Sheet, April 2009: http://books.sipri.org/files/FS/SIPRIFS0904.pdf

[40] Roger Cliff, testimony before the U.S.-China Economic and Security Review Commission hearing on "China's Military Modernization and U.S. Export Controls," March 16-17, 2006: http://www.uscc.gov/hearings/2006hearings/transcripts/march16_17/March_16-17_FINAL.pdf

[41] Phillip C. Saunders and Erik R. Quam, "China's Air Force Modernization," *Joint Force Quarterly*, Issue 47, 4th Quarter 2007: http://www.ndu.edu/inss/Press/jfq_pages/editions/i47/7.pdf

[42] Some import-export companies specialize in both import of technology and export of finished military products. One such example is the China Precision Machinery Import-Export Corporation (CPMIEC), which is the trading arm of China Aerospace Science and Industry Corporation (CASIC).

[43] China's AWACS program was dealt a severe blow in June 2006 when 35 electronics and avionics technicians were killed along with the flight crew of a KJ-2000 aircraft that crashed in Anhui Province. See Joseph Kahn, "Crash of Chinese Surveillance Plane Hurts Effort on Warning System," *New York Times*, June 7, 2006: http://query.nytimes.com/gst/fullpage.html?res=9406E5D71431F934A35755C0A9609C8B63

[44] "KongJing-2000 Airborne Warning & Control System," SinoDefence.com, January 4, 2009.

glimpse into the scope of China's foreign technology purchases and is not intended to be an exhaustive treatment of the subject.

1.1 **Russia**

Despite almost three decades of hostility between the U.S.S.R. and the PRC following the Sino-Soviet split, Russia reemerged at the conclusion of the Cold War as China's principal foreign supplier of advanced weapons. China, then embarking on a rapid modernization of its armed forces after sobering to U.S. military capabilities during the Persian Gulf War, began to purchase large quantities of military technologies from abroad. Meanwhile, the eagerness of Russia's cash-strapped defense industry for outside currency helped thaw the previously frosty relationship between the two countries.[45] Since then, Russia has accounted for roughly 85 percent of China's weapons imports.[46] According to Larry Wortzel, a former U.S. Army attaché in Beijing and current member of the U.S.-China Economic and Security Review Commission, these investments have allowed China to bypass perhaps 30 to 40 years of military R&D.[47] While Russia sells a vast assortment of military technology to China, the staples of arms trade between the two nations consists of big-ticket weapons systems such as fighter and bomber aircraft, submarines, and naval surface vessels. The 2005 annual DoD report on Chinese military power asserted that Russian conventional arms transfers had "advanced the lethality of every major category of weapon system under development in China."[48]

The following sub-sections provide a partial description of various advanced weapons systems that the PRC has acquired from Russia over the previous two decades.[49]

1.1.1 **Advanced Aircraft and Engine Technology**

In the early 2000s, the PRC took possession of roughly 100 Russian Su-30MKK multi-role fighter aircraft, adding to its fleet of Su-27SK fighters that had been purchased beginning in 1992. Additionally, in 2004, China accepted delivery of 24 Su-30 MK2 aircraft, an upgraded version with improved avionics and naval strike capabilities.[50] Together with the Chinese-made J-10 fighter, these aircraft form the backbone of the PLAAF fighter force.[51] A 2005 announcement that China would purchase eight Russian Il-78 aerial refueling tankers signaled the PRC's interest in extending the range of its fighter fleet. The deal also suggested that China's indigenous refueling tanker, the Xian H-6, based on the Russian Tu-16 Badger, was inadequate.[52]

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[45] Richard Fisher, Jr., "Military Sales to China: Going to Pieces," *China Brief*, Volume 2, Issue 23, November 21, 2002: http://www.strategycenter.net/research/pubID.14/pub_detail.asp

[46] *Annual Report to Congress: Military Power of the People's Republic of China 2005.* Office of the Secretary of Defense: http://www.defenselink.mil/news/Jul2005/d20050719china.pdf

[47] "Reframing China Policy Debate 3: Is China's Military Modernization Program a Growing Threat to the United States and Asia?" Carnegie Endowment for International Peace, New Vision Program, February 6, 2007: www.carnegieendowment.org/files/debate_3%20final%20transcript.pdf

[48] *Annual Report to Congress: Military Power of the People's Republic of China 2005.* Office of the Secretary of Defense: http://www.defenselink.mil/news/Jul2005/d20050719china.pdf

[49] In addition to acquiring hardware and weapons technology, Chinese military cooperation with Russia includes incorporating the latter's warfighting doctrine. For example, in 2005 the first-ever joint military exercise between the two countries took place with "Peace Mission 2005." See Martin Andrew, "Power Politics: China, Russia, and Peace Mission 2005," *China Brief*, Volume 5, Issue 20, October 27, 2005. In this simulation, upwards of 10,000 Chinese and Russian personnel took part in eight days of mock amphibious assaults and drills involving submarines, long-range bombers, and other weapons platforms. A subsequent "Peace Mission 2007," held in August 2007 under the auspices of the Shanghai Cooperation Organization, featured 4,000 Russian and Chinese troops. See Sergei Blagov, "Thorns in the rosy China-Russia relationship," *Asia Times*, August 15, 2007: http://www.atimes.com/atimes/Central_Asia/IH15Ag01.html

[50] "Su-30MKK Multirole Fighter Aircraft," SinoDefence.com, February 20, 2009, http://www.sinodefence.com/airforce/fighter/su30.asp

[51] "China Buying Russian Combat Jets," *Arms Control Today*, March 2003: http://www.armscontrol.org/node/3256

[52] "Il-78 Tanker," SinoDefence.com, April 25, 2007: http://www.sinodefence.com/airforce/airlift/il78.asp

In addition to outright aircraft sales, many Russian components have been incorporated into Chinese aircraft that are otherwise considered indigenously produced. For example, Russian Saturn AL-31 turbofan engines power China's J-10 fighter, which is often described as an indigenous aircraft but was in fact the recipient of considerable Russian technical guidance.[53] According to one recent report, the "production of current-day jet engines that are reliable and operate at acceptable levels of military efficiency still eludes most of China's aerospace sector."[54] Russian engine manufacturers apparently take pains to restrict the PRC's access to the underlying technology, producing engines in Russia according to Chinese specifications and delivering them in their final state to minimize technology transfer.[55]

1.1.2 **Submarines**

China has purchased a total of 12 Kilo-class submarines from Russia. These diesel-electric submarines are primarily designed for anti-ship and anti-submarine warfare; their relatively quiet diesel propulsion system allows for stealthy operations in shallow littoral zones.[56] China's heavy investment in submarine capabilities corresponds with a long-term area-denial maritime strategy, which Robert D. Kaplan describes as "developing asymmetric niche capabilities designed to block the U.S. Navy from entering the East China Sea and other Chinese coastal waters."[57]

Advanced Russian sonar systems acquired as part of the Kilo acquisitions, including the MG-519 Mouse Roar and MGK-500 Shark Gill, have reportedly been incorporated into the PRC's Yuan-class diesel-electric submarine. Introduced in 2004, the Yuan class is reportedly a hybrid of both Chinese and foreign submarine technologies. This admixture was described in the 2002 DoD report on Chinese military power, which predicted that China would "continue using Russian technology to improve quieting, propulsion, and submarine design…"[58] The report also observed that while China is incorporating foreign technology into its submarine fleet, the People's Liberation Army Navy (PLAN) will "benefit from the maturation of its domestic submarine R&D infrastructure to achieve a capability to design and manufacture modern submarines domestically."[59]

1.1.3 **Surface Vessels**

Among the most closely studied dimensions of the PLA's modernization is its effort to build a "blue water" navy—a fleet capable of projecting power to distant waters and not simply patrol China's littoral.[60] In a 2008 interview, strategist Chen Zhou of the Academy of Military Sciences noted that while China has traditionally viewed itself as a land power, "foreign powers were able to invade us because we had no navy....To more effectively protect our national interests, we will develop our capability to operate on the high seas."[61]

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[53] "Jian-10 Multirole Fighter Aircraft," Sinodefence.com, March 21, 2009: http://www.sinodefence.com/airforce/fighter/j10.asp
[54] Reuben F. Johnson, "China eager for Russian air technology," *Washington Times*, May 4, 2010: http://www.washingtontimes.com/news/2010/may/04/china-eager-for-russian-air-technology/print/
[55] Ibid.
[56] "Kilo Class," GlobalSecurity.org, January 12, 2007: http://www.globalsecurity.org/military/world/china/kilo.htm
[57] Robert D. Kaplan, "The Geography of Chinese Power," *Foreign Affairs*, Volume 89, Number 3, May/June 2010.
[58] *Annual Report on the Military Power of the People's Republic of China.* Report to Congress Pursuant to the FY2000 National Defense Authorization Act: http://www.defense.gov/news/Jul2002/d20020712china.pdf
[59] Ibid.
[60] See Ronald O'Rourke, "China Naval Modernization: Implications for U.S. Navy Capabilities: Background and Issues for Congress," Congressional Research Service, November 18, 2005: http://fpc.state.gov/documents/organization/57462.pdf; see also Robert D. Kaplan, "How We Would Fight China," *The Atlantic Monthly*, June 2005: http://richblass.com/documents/Extra%20Credit/Kaplan_China.pdf
[61] Siegesmund von Ilsemann and Andreas Lorenz, "SPIEGEL Interview with Top Chinese Military Strategist," *Der Spiegel*, March 19, 2008: http://www.spiegel.de/international/world/0,1518,542506,00.html

In keeping with this ambition, between 1999 and 2000, the PLAN took delivery of two Russian *Sovremenny* class destroyers, with a second pair entering the fleet several years later.[62] These vessels feature advanced anti-ship cruise missiles as well as technologies of mixed Russian and Chinese lineage. China's new Luyang II-class guided missile heavy destroyer, designed to provide ship-based area air defense and thereby support longer-range power projection, is ostensibly outfitted with "indigenous" technologies. However, like many Chinese military systems, the destroyers lean heavily on technology and design expertise acquired through Russian arms sales.

1.1.4 **Carrier-based Aviation**

According to numerous reports, Chinese leaders have essentially confirmed that the PLAN will field an aircraft carrier battle group in the coming years.[63] In March 2009, PRC Defense Minister General Liang Guanglie made remarks to Japan's Defense Minister Yasukazu Hamada that were widely construed as confirming China's decision to acquire a carrier. Noting that "China is the only major country in the world that doesn't have an aircraft carrier," Liang suggested that "China cannot be without an aircraft carrier forever."[64] A month later PLAN Admiral Wu Shengli made reference to China's plans for "large combat warships," widely interpreted as a signal of its carrier ambitions.[65]

In 1985 the PRC purchased the Majestic-class carrier HMAS *Melbourne* from Australia. The purchase was seen as assisting the Chinese aircraft carrier program in two principal areas: the Melbourne allowed Chinese engineers to study the basic design of the vessel, contributing to their understanding of carrier construction requirements, and the dismantled flight deck was used to train Chinese pilots for future carrier flight operations.[66] In the 1990s, China also acquired three Russian aircraft carriers, the sister ships *Minsk* and *Kiev,* both used in military theme parks, and the Soviet-era *Kuznetsov*-class carrier *Varyag*, whose purchase was more ambiguous.[67]

According to Naval War College professor Andrew Erickson, China's reported refurbishment of the *Varyag* should be seen as "part one of a two-part approach—outfit a foreign-purchased platform to enable basic training, while preparing a more capable [indigenously produced] platform for higher-level military operations."[68] Several reports in late 2009 suggested that China had already embarked on a program to construct an indigenous aircraft carrier in the 50,000-60,000 ton class, possibly using the *Varyag* design, at the China State Shipbuilding Corporation's Changxing Island Shipyard.[69] (The *Varyag* has reportedly been renamed *Shi Lang* after a Qing Dynasty admiral who conquered the province that is now Taiwan in 1681.)

Xu Guangyu, a retired PLA general, has indicated that China's first carrier would feature a ski-jump take-off given Chinese engineers' inability to master magnetic or steam-powered catapults, which U.S. carriers

[62] "Project 956/EM Sovremenny Class Missile Destroyer," SinoDefence.com, February 28, 2009: http://www.sinodefence.com/navy/surface/sovremenny.asp
[63] Edward Wong, "Chinese Military Seeks to Extend Its Naval Power," *New York Times*, April 24, 2010: http://www.nytimes.com/2010/04/24/world/asia/24navy.html
[64] Kristine Kwok, "With aircraft carrier remarks, minister sends a message," *South China Morning Post*, March 24, 2009.
[65] Christopher Bodeen, "China's first aircraft carrier on horizon," Associated Press, April 21, 2009: http://seattletimes.nwsource.com/html/nationworld/2009091966_chinanavy21.html
[66] Ian Storey and You Ji, "China's Aircraft Carrier Ambitions: Seeking Truth from Rumors," *Naval War College Review*, Volume 57, Number 1, Winter 2004.
[67] Storey and You, op. cit.
[68] Greg Torode, "PLA's first carrier 'ready by 2012'; Blue-water navy plans advancing, US says," *South China Morning Post*, April 1, 2010.
[69] Andrei Chang, "China ready to build its first aircraft carrier," *United Press International*, June 4, 2009.

utilize.[70] The *Varyag* is equipped with a ski-jump.[71] As further evidence of China's intention to pursue a ski-jump-based carrier based on Russian designs, Chinese pilots have reportedly been receiving simulator training at Ukraine's Research Test and Flying Training Center (NITKA), which was formerly the chief training site for Soviet-era pilots operating from ski-jump carriers. Several open-source accounts indicate that China has purchased carrier landing equipment and tailhooks.[72] Additionally, the 2009 DoD report on Chinese military power noted that China "continues to show interest in procuring Sukhoi Su-33 carrier-borne fighter aircraft from Russia."[73] However, Russian negotiators reportedly halted China's planned acquisition of Su-33 fighters after learning of Chinese effort to copy the Su-27SK.[74] In 2009, reports suggested that China had obtained a prototype Su-33 from Ukraine for the purpose of cloning the fighter in support of its carrier program.[75]

1.1.5 **Cruise Missiles**

In 2008, the annual DoD assessment of Chinese military power noted that the PRC was acquiring significant numbers of highly accurate cruise missiles. The report specifically listed the Russian-made SS-N-22/Sunburn supersonic anti-ship cruise missile (ASCM) and the SS-N-27B/Sizzler ASCM.[76] Much of the technology incorporated into China's cruise missile program is the product of its campaign to acquire cruise missile technology from Russia, Ukraine, and, to a lesser extent, Belarus.[77] (For further discussion of Chinese cruise missiles, see Case Study: Land Attack Cruise Missiles.)

1.1.6 **Air Defense**

In keeping with China's decades-old emphasis on anti-access capabilities, in April 2010 the PRC received 15 batteries of Russia's S-300 air-defense system as part of a deal estimated at more than $2 billion.[78] The S-300, a system widely sold to traditional Russian arms-buyers such as Iran, India, and Serbia, has a 90-mile range and can be used against both cruise missiles and aircraft. Open-source reports suggest that China is attempting to replicate the technology used in the S-300 system.[79]

In addition to outright arms transfers between the two countries, China and Russia have reportedly participated in joint research concerning a number of military technologies, including laser technology, nuclear weapon miniaturization, and space-based weapons. According to Taiwanese Major General Tyson Fu, the former head of the Institute of Strategic Studies of Taiwan's National Defense University, "The weapons don't concern us as much as the technology transfers do." It is in this realm of the cooperative relationship that "the Russians are making their biggest impact."[80]

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[70] Minnie Chan, "Challenge will be training pilots, ex-general says," *South China Morning Post*, April 1, 2010.
[71] Ian Storey and You Ji, "China's Aircraft Carrier Ambitions: Seeking Truth from Rumors," *Naval War College Review*, Volume 57, Number 1, Winter 2004.
[72] Andrei Chang, "Analysis: Ukraine aids China carrier plan," *United Press International*, December 10, 2008: http://www.spacewar.com/reports/Analysis_Ukraine_aids_China_carrier_plan_999.html
[73] *Annual Report to Congress: Military Power of the People's Republic of China 2009*. Office of the Secretary of Defense: http://www.defense.gov/pubs/pdfs/China_Military_Power_Report_2009.pdf
[74] Wendell Minnick, "Is China Stealing Russia's Su-33?" *Defense News*, May 4, 2009: http://www.defensenews.com/story.php?i=4070484
[75] Minnick, op. cit.
[76] *Annual Report to Congress: Military Power of the People's Republic of China 2008*, Office of the Secretary of Defense: http://www.defenselink.mil/pubs/pdfs/China_Military_Report_08.pdf
[77] *Annual Report on the Military Power of the People's Republic of China*, Report to Congress Pursuant to the FY2000 National Defense Authorization Act, June 2000: http://www.defenselink.mil/news/Jun2000/china06222000.htm
[78] Dmitry Solovyov, "China buys air defense systems from Russia," Reuters, April 2, 2010: http://www.reuters.com/article/idUSTRE6310WG20100402
[79] Wendell Minnick, "China Shifts Spending Focus to Info War," *Defense News*, September 2006.
[80] John Pomfret, "Russians Help China Modernize its Arsenal; New Military Ties Raise U.S. Concerns," *Washington Post*, February 10, 2000.

1.2 **Ukraine**

Another PRC source of advanced military hardware is Ukraine, which possess a relatively sophisticated defense industry as a legacy of its inclusion in the Soviet military machine. In addition to acknowledged Sino-Ukrainian defense ties, Ukraine has been the source of several illicit Chinese arms purchases of advanced systems. Notable among these is the alleged transfer to China of a prototype Su-33 fighter from Ukraine's NITKA, which was supposedly acquired for the purpose of cloning the aircraft in support of China's aircraft carrier program.[81] Specifically, the Ukrainian aircraft provided the Chinese with insight into folding-wing technology. The Chinese prototype version of the fighter, manufactured indigenously by the Shenyang Aircraft Company, has been dubbed the J-15.[82]

Additionally, media reports revealed in 2005 that six Kh-55 medium-range, air-launched nuclear-capable cruise missiles were illicitly transferred from Ukraine to China by an international criminal group.[83] China's new Luyang-class destroyers are also reportedly outfitted with Ukrainian DA80/DN80 gas turbine engines manufactured in China under license.

Ukrainian R&D entities, such as the Academy of Sciences, have established cooperative relationships with counterparts in China, such as the Aerospace Research Institute of Materials and Processing Technology, to help overcome specific technological hurdles, such as heating of re-entry vehicles. More specifically, collaboration has focused on advanced ablative heat resistant materials for maneuvering boost-glide re-entry vehicles. The Academy also has aerospace-related partnerships with Northwestern Polytechnical University in Xian and Harbin Institute of Technology in Harbin.[84]

1.3 **Europe**

A number of European countries have served as sources of advanced weapons for the PRC despite the European Union (EU) ban on arms sales following the 1989 Tiananmen Square crackdown.[85] Unlike the United States, which enacted strict legislation prohibiting weapon sales to China, the EU ban was nonbinding and was left to the individual interpretation of European governments. While some EU countries refrain from military sales of any kind to China, others permit transactions involving non-lethal technology that is nevertheless military in nature.[86] Among the European systems sold to China since 1989 are the six-blade R-408 aircraft propeller made by the British firm Dodi, which is used on China's Y-8 Airborne Early Warning System;[87] Alenia Aspide air-to-air missiles, a version of the U.S. Sparrow missile, purchased from Italy; and avionics for the F-7M and F-7MP fighter aircraft, including British-made heads-up displays, targeting systems, and fire control radar as well as Italian fire control radar.[88]

[81] Wendell Minnick, "Is China Stealing Russia's Su-33?" *Defense News*, May 4, 2009: http://www.defensenews.com/story.php?i=4070484

[82] "China Making First J15 Ship-Borne Fighter," *Kanwa Asian Defense*, May 1, 2010. Open Source Center: CPP20100511702017.

[83] Paul Kerr, "Ukraine Admits Missile Transfers," *Arms Control Today*, May 2005: http://www.armscontrol.org/act/2005_05/Ukraine

[84] See the Academy of Science's website: http://www.ipp.kiev.ua/about/conne_e.htm; see also Mark A. Stokes, "China's Evolving Conventional Strategic Strike Capability," Project 2049 Institute Occasional Paper, September 14, 2009, p. 117 (footnote 128): http://project2049.net/documents/chinese_anti_ship_ballistic_missile_asbm.pdf

[85] Richard F. Grimmett and Theresa Papademetriou, "European Union's Arms Control Regime and Arms Exports to China: Background and Legal Analysis," Congressional Research Service, March 1, 2005: http://www.fas.org/sgp/crs/row/RL32785.pdf

[86] "Undermining Global Security: the European Union's arms exports," Amnesty International, February 1, 2004: http://www.amnesty.org/en/library/info/ACT30/003/2004

[87] Erik Lin-Greenberg, "Offensive Airpower with Chinese Characteristics," *Air & Space Power Journal* , Fall 2007: http://www.airpower.maxwell.af.mil/airchronicles/apj/apj07/fal07/greenberg.html

[88] "U.S. and European Union Arms Sales since the 1989 Embargoes," General Accounting Office, GAO/T-NSIAD-98-171, April 28,1998: http://www.gao.gov/archive/1998/ns98171t.pdf

In 2005, the Eurocopter subsidiary of European aerospace corporation EADS entered into an agreement with Aviation Industries of China II (AVIC-II) to develop the EC175, a 16-seat "civil" helicopter.[89] The Chinese military version of this helicopter, the Harbin Z-15, is expected to be delivered to the PLA between 2015-2020 for use in support, antisubmarine warfare, and search and rescue functions.[90] Similar collaborations between Chinese and European firms on civil aircraft have in the past produced variations for military use. For example, China's license to produce the Eurocopter AS 365N Dauphin II in 1980 gave way to its development of the Zhi-9 military helicopter, now in PLA service in army utility, naval, and attack roles.[91]

1.4 **Pakistan**

The cooperative military relationship between China and Pakistan, an outgrowth of the countries' mutual rivalry with India, is now approaching its sixth decade. Both nations have been the recipients of the other's arms and technology, and joint weapons development programs have also occurred, although Pakistan generally plays the role of the junior partner in the relationship. In the early 1990s, reports indicated that the U.S. intelligence community was concerned that Pakistan had surreptitiously provided China with Stinger anti-aircraft missiles, to which the Pakistanis had access as a result of their assistance to the United States during the Soviet war in Afghanistan. Pakistan's Inter-Services Intelligence agency (ISI) had helped the United States provide arms and training to anti-Soviet Afghan mujahideen. As many as 300 Stingers may have been unaccounted for after the Soviet withdrawal, sparking fears that Pakistan had provided some units to China.[92]

Beyond mere arms sales and technology transfers, Chinese and Pakistani technical personnel have collaborated to produce a number of weapons systems. A notable example is the JF-17/ FC-1 fighter, developed jointly by China's Chengdu Aircraft Industries Corporation and the Pakistan Aeronautical Complex.[93] Known in China as the FC-1 Fierce Dragon and in Pakistan as the JF-17 Thunder, the aircraft is the product of a $500 million joint development effort that began in 1999.[94] Other joint aircraft development programs include the Hongdu JL-8 light attack fighter, known by its Pakistani designation as the K-8 Karakorum.

Sino-Pakistani military cooperation is not limited to conventional weapons. According to media reports, it also extends to the most prized strategic capabilities in both countries' arsenals. In 2009, several sensational accounts suggested that during the late 1970s and early 1980s, Pakistan and China established a symbiotic nuclear relationship. Drawn from the writings of A.Q. Khan, the Pakistani scientist accused of masterminding a global nuclear proliferation ring, these reports assert that China provided Pakistan with substantial quantities of uranium hexafluoride gas to feed its uranium enrichment centrifuges in exchange for Pakistan's sharing of its centrifuge technology. Pakistan's centrifuges, based on technology that Khan had procured illicitly from Europe, were then considered superior to Chinese designs. As part

[89] "EADS to Co-develop EC175 Helicopter With China," *Defense Industry Daily*, December 7, 2005: http://www.defenseindustrydaily.com/eads-to-codevelop-ec175-helicopter-with-china-01585/
[90] "Zhi-15 (EC 175) Medium Helicopter," SinoDefence.com, March 15, 2008: http://www.sinodefence.com/airforce/helicopter/z15.asp
[91] "Zhi-9 Utility Helicopter," SinoDefence.com, January 2, 2009: http://www.sinodefence.com/airforce/helicopter/z9.asp
[92] "Intelligence: Sting in the tail," *Far Eastern Economic Review;* October 28, 1993. p. 9.
[93] Wendell Minnick, "China Shifts Spending Focus to Info War," *Defense News*, September 2006.
[94] "FC-1 / JF-17 Multirole Fighter Aircraft," SinoDefence.com, March 13, 2009: http://www.sinodefence.com/airforce/fighter/fc1.asp

of the transaction between the two countries, Khan alleges that China later provided Pakistan with 50 kilograms of highly enriched uranium as well as the blueprint for a rudimentary nuclear weapon.[95]

1.5 **United States**

Perhaps the least intuitive source of China's advanced technology is the United States, which, notwithstanding the current chill between the two countries, was once an enthusiastic enabler of Beijing's military modernization, if only briefly. As Jonathan Pollack recounts, following the normalization of Sino-American relations after President Nixon's 1972 trip to China, successive American presidents sought to increase PRC military capabilities as a strategic counterweight to the Soviet Union. As part of this late Cold War-era policy, China was given access to a number of advanced U.S. systems.[96] Reagan-era arms sales to China included MK 46 Mod 2 anti-submarine warfare torpedoes, AN/TPQ-37 counterartillery radar, and UH-60 Black Hawk helicopters.[97] Especially significant was a $500 million dollar sale called the "Peace Pearl" program to equip PLAAF F-8-II fighters with advanced radar and avionics to improve their performance against Soviet aircraft.[98] However, this relationship was effectively terminated in the wake of Tiananmen Square.[99]

During the 1990s, military-to-military (mil-to-mil) contacts between the United States and the PRC were tepidly restored. These contacts did not involve weapons sales or technology transfers but were instead aimed primarily at increasing transparency and building trust between the two countries' militaries. However, these "engagement activities" occasionally drew criticism from U.S. lawmakers and military officials who feared that cooperation with China could improve its military capabilities and compromise U.S. national security. For example, in 1999 American media reports revealed the existence of an exchange program between PLA officers and U.S. officials. These reports sparked hostile reactions from several U.S. legislators, who asserted that the exchanges could improve Chinese warfighting capabilities in such areas as logistics and airborne operations.[100] Later that year, Larry Wortzel alleged that mil-to-mil contacts had given PLA officers "broad access to U.S. warships, exercises, and even military manuals." Cautioning that these exchanges "should be approached with extreme caution," Wortzel asserted that "military contacts between the United States and China over the years helped the PLA attain its [military modernization] goals."[101]

[95] R. Jeffrey Smith and Joby Warrick, "A Nuclear Power's Act of Proliferation," *Washington Post*, November 13, 2009: http://www.washingtonpost.com/wp-dyn/content/article/2009/11/12/AR2009111211060.html?hpid=topnews. See also Simon Henderson, "Investigation: Nuclear scandal–Dr Abdul Qadeer Khan," *The Sunday Times*, September 20, 2009.

[96] Richard P. Suttmeier, "From Cold War Science Diplomacy to Partnering in a Networked World: 30 Years of Sino-US Relations in Science and Technology," Earlier version presented at the 2009 Hixon Forum on "Science and Technology in the Making of Modern China," February 27-28, 2009: http://china-us.uoregon.edu/pdf/030409.pdf

[97] Jonathan D. Pollack, 1999. See also Shirley A. Kan, "U.S.-China Military Contacts: Issues for Congress," Congressional Research Service, April 15, 2009: http://www.au.af.mil/au/awc/awcgate/crs/rl32496.pdf; Bates Gill and Taeho Kim, *China's Arms Acquisitions from Abroad: A Quest for "Superb and Secret Weapons,"* Oxford University Press, 1995. pp. 42-43.

[98] "Polishing the Pearl," *The Economist*, June 11, 1988. See also Kenneth W. Allen and Eric A. McVadon, "China's Foreign Military Relations," Henry L. Stimson Center, October 1999: http://www.stimson.org/china/pdf/chinmil.pdf

[99] Eden Y. Woon, "Chinese Arms Sales and U.S.-China Military Relations," Asian Survey, Volume 29, Number 6, June 1989: http://www.jstor.org/stable/2644755

[100] Bill Gertz, "Military exchange with Beijing raises security concerns," *Washington Times*, February 19, 1999.

[101] Larry Wortzel, "Why Caution is Needed in Military Contacts with China," Heritage Foundation Backgrounder, December 2, 1999: http://www.heritage.org/Research/Reports/1999/12/Why-Caution-Is-Needed-in-Military-Contacts-with-China

SECTION 2: UNSANCTIONED ALLIANCES

As the possessor of the world's largest military, an armed force that is now in its second decade of rapid modernization, the PRC maintains an extensive network of both suppliers and recipients of military hardware. As its 2006 White Paper on National Defense noted, China's military ties include dealings with more than 150 nations.[102] Most of these relationships are publicly declared and unambiguous. As described in the preceding section, Russia and other advanced military powers are the sources of defense technology that China makes no secret of acquiring. Another category includes the "unsanctioned alliances" between China and a small number of supplier states with whom it has less public ties. These partnerships might be described as formal cooperative relations between two nations that, because of various political sensitivities, neither wishes to advertise. The following section summarizes what is arguably the most strategically important unsanctioned alliance that China maintains—its relationship with the State of Israel.

Israel

Of the cooperative military relationships the PRC maintains with foreign partners, perhaps none is more controversial nor furtive than its partnership with Israel, a major supplier of China's advanced weapons technologies. Military cooperation between Israel and the PRC dates back at least to 1979. However, the present status of the relationship is unclear following several highly public disagreements in the 2000s between Israel and the United States over the former's arms dealings with China. These incidents are discussed in greater detail below.

China's attraction to Israeli arms was initially rooted not only in the advancement of its weapons systems but also in its expertise concerning weapons produced by the Soviet Union, both China's great rival and the source of much of its military hardware. As Professor Yitzhak Shichor of Hebrew University observes, "[n]o other country had accumulated as much experience in fighting Soviet weapons, or in upgrading and integrating them into its own arsenal."[103] The establishment of formal diplomatic relations between the two countries in 1992 greatly accelerated arms sales and technology transfers.[104] Among the world's leading producers of advanced arms, Israel has provided China with much of the technology it has sought in its drive to modernize the PLA. These capabilities include fighter aircraft technology, unmanned aerial vehicles (UAVs), communications and optical equipment, radar systems, electronic warfare systems, and an assortment of missiles.[105] According to the 2002 report of the U.S.-China Economic and Security Review Commission, in the volume of its arms sales, Israel is surpassed only by Russia as a supplier of sophisticated weapons systems to China.[106]

A 1985 news report described China's modernization drive as "aimed at achieving rapid industrial development by adopting Western methods and technology from any country willing to sell it," a policy

[102] China's National Defense in 2006, Information Office of the State Council of the People's Republic of China, December 2006, Beijing: http://english.peopledaily.com.cn/whitepaper/defense2006/defense2006.html
[103] Yitzhak Shichor, "Israel's Military Transfers to China and Taiwan," *Survival*, Volume 40, Number 1, Spring 1998.
[104] Cnaan Liphshiz, "China marks 17 years with Israel," *Haaretz*, September 27, 2009: http://www.haaretz.com/hasen/spages/1116961.html
[105] Kenneth W. Allen and Eric A. McVadon, "China's Foreign Military Relations," Henry L. Stimson Center, October 1999: http://www.stimson.org/china/pdf/chinmil.pdf
[106] *The National Security Implications of the Economic Relationship Between the United States and China*, annual report of the U.S.-China Economic and Security Review Commission, 2002: http://www.uscc.gov/annual_report/2002/ch10_02.htm

that has dovetailed nicely with Israel's reported liberality in selling restricted military technology.[107] For this reason the Sino-Israeli relationship, described in a Stimson Center analysis as one of China's "most secretive," has been a source of concern to the United States for over two decades.[108] Many U.S. analysts have characterized the partnership as offering the Chinese a "back door" to Western technologies.[109] In 1993 Senate testimony, for example, former Director of Central Intelligence James Woolsey suggested that China had received advanced weapons from Israel for more than a decade and that by 1989 Israel had become China's chief source of high-tech arms. Woolsey elaborated that "the Chinese seek from Israel advanced military technologies that U.S. and Western firms are unwilling to provide" and that "the Chinese would have difficulty producing on their own."[110] In several instances these transfers have occurred in spite of formal agreements among Western governments to restrict Chinese access to advanced technologies. In addition to the United States, source nations are reported to include the United Kingdom, Germany, and France.[111]

In 1992, the U.S. intelligence community alleged that Israel had transferred U.S.-provided Patriot anti-missile technology China in violation of an agreement with the United States not to transfer the technology to third countries.[112] China's interest in the technology was apparently rooted in an effort to increase the performance of its own hit-to-kill capabilities, as well as to equip its ballistic and cruise missiles with countermeasures to defeat Patriot systems deployed by the United States and Taiwan. Though a subsequent State Department investigation concluded that "no evidence that Israel had transferred a Patriot missile or Patriot missile technology" had been found,[113] the accompanying report confirmed that allegations of Israel's circumvention of U.S. arms export laws "supported by reliable intelligence information show a systematic and growing pattern of unauthorized transfers…"[114] (While the unclassified version of the report identified the offender only as "a major recipient of United States weapons and technology," U.S. officials later confirmed that the reference concerned Israel.)[115]

Two years after the Patriot controversy, information surfaced that China's J-10 fighter aircraft had incorporated technology from Israel's "Lavi" fighter program, which itself had been the beneficiary of American F-16 technology before the Lavi's termination in 1987.[116] Speculation on Chinese interest in Lavi avionics had been aired in the open literature for several years before the revelation.[117] In an unclassified assessment released in 1996, the U.S. Office of Naval Intelligence stated flatly that "United

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[107] Thomas L. Friedman, "Israel and China Quietly Form Trade Bonds," *New York Times*, July 22, 1985.
[108] Kenneth W. Allen and Eric A. McVadon, "China's Foreign Military Relations," Henry L. Stimson Center, October 1999: http://www.stimson.org/china/pdf/chinmil.pdf; Yitzhak Shichor also refers to the "secret nature of Sino-Israeli military relations." See Yitzhak Shichor, "Israel's Military Transfers to China and Taiwan," *Survival*, Volume 40, Number 1, Spring 1998.
[109] Richard A. Bitzinger, "Arms to Go: Chinese Arms Sales to the Third World," *International Security*, Volume 17, Number 2, Autumn 1992; Michael R. Gordon, "Israel Selling China Military Technology, C.I.A. Chief Asserts," *New York Times*, October 12, 1993.
[110] "Proliferation Threats of the 1990's," Hearing before the Senate Committee on Governmental Affairs, February 24, 1993: http://www.archive.org/stream/proliferationthr00unit/proliferationthr00unit_djvu.txt. As cited in Duncan Clarke, "Israel's Unauthorized Arms Transfers," Foreign Policy, Number 99, Summer 1995: http://www.jstor.org/pss/1149008.
[111] Bates Gill and Taeho Kim, *China's Arms Acquisitions from Abroad: A Quest for "Superb and Secret Weapons,"* New York: Oxford University Press, 1995. p.83.
[112] "If Israel Sold Patriot Secrets…" *New York Times*, March 20, 1992: http://www.nytimes.com/1992/03/20/opinion/if-israel-sold-patriot-secrets.html
[113] Patrick E. Tyler, "No Evidence Found of Patriot Sales by Israel to China," *New York Times*, April 3, 1992: http://www.nytimes.com/1992/04/03/world/no-evidence-found-of-patriot-sales-by-israel-to-china.html
[114] Duncan Clarke, "Israel's Unauthorized Arms Transfers," Foreign Policy, Number 99, Summer 1995: http://www.jstor.org/pss/1149008
[115] Tyler, 1992.
[116] Jim Mann, "U.S. Says Israel Gave Combat Jet Plans to China," *Los Angeles Times*, December 28, 1994.
[117] James P. DeLoughry, "The United States and the LAVI," *Airpower Journal*, Volume IV, Number 3, Fall 1990: http://www.fas.org/man/dod-101/sys/ac/row/3fal90.htm

States technology has been acquired through Israel in the form of the Lavi fighter..."[118] To varying degrees, China and Israel continue to deny that the transfer occurred. While disclaiming any official Israeli approval of a Lavi technology transfer, David Ivry, the head of Israel's Ministry of Defense, admitted that "some technology on aircraft" had been passed to China and that Israeli defense corporations may not have "clean hands."[119] The chief Chinese designer of the J-10, Song Wencong, scoffed at allegations of foreign participation in what he insisted was a wholly indigenous development effort; Song called suggestions that the J-10 is a copy of the Lavi "just laughable."[120]

Among the advanced weapons and technological assistance Israel is believed to have provided to China are laser-guided armor-piercing warheads, surface-to-air missiles, electronic fire-control systems, night-vision equipment, communications systems, and anti-tank missiles.[121] A British 105mm rifled gun incorporated in China's Type 69 main battle tank was reportedly acquired from Israel, which manufactured the component under license.[122] Israel also allegedly assisted China in producing a copy of the Gabriel sea-skimming anti-ship missile.[123] In another controversial arrangement, Israel sold China the Rafael Python-3 air-to-air missile, which to some U.S. analysts looks "suspiciously like a knock-off of an American design, the heat-seeking AIM-9L Sidewinder."[124] The Chinese version of the missile, the PL-8, was produced under license by Chinese manufacturers beginning in 1988.[125]

In the late 1980s, Tel Aviv was implicated in an arrangement in which Israeli technicians helped improve the guidance system of China's medium-range CSS-2 "East Wind" missiles.[126] The 1998 discovery of China's sale of approximately 50 CSS-2 missiles to Saudi Arabia sparked an international uproar rooted in concern that the deal signaled Saudi interest in nuclear weapons.[127] China's Han-class submarines, which must surface before firing their missiles, appear to have been fitted with Israeli radar technology that provides its anti-ship missiles with crucial over-the-horizon reach.[128]

Perhaps the most widely known example of Sino-Israeli military cooperation is the aborted Phalcon deal, in which Israeli Aircraft Industries contracted with the PLA in 1996 to outfit several Russian Beriev A-50 aircraft with the Israeli EL/M-2075 Phalcon AEW radar system. In response to American concerns that

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[118] "Worldwide Challenges to Naval Strike Warfare," U.S. Office of Naval Intelligence, Washington, D.C., January 1996: http://handle.dtic.mil/100.2/ADA314821

[119] David Isenberg, "Israel's role in China's new warplane," *Asia Times*, December 4, 2002: http://www.atimes.com/atimes/China/DL04Ad01.html. See also Duncan Clarke, "Israel's Unauthorized Arms Transfers," *F*oreign Policy, Number 99, Summer 1995.

[120] "Exclusive Interview with J-10 General Designer Song Wencong," 2007: http://military.china.com/zh_cn/news/568/20070105/13858504.html

[121] P.R. Kumaraswamy, "The Military Dimension of Israel-China Relations," *China Report* 1995; 31; 235.

[122] "Type 69/79 Main Battle Tank," SinoDefence.com, February 20, 2009: http://www.sinodefence.com/army/tank/type69.asp; see alsoThomas L. Friedman, "Israel and China Quietly Form Trade Bonds," *New York Times*, July 22, 1985; and Yitzhak Shichor, "Israel's Military Transfers to China and Taiwan," *Survival*, Volume 40, Number 1, Spring 1998.

[123] Jon Swain, "Israel in secret missile deal with China," *Sunday Times* (London), April 3, 1988. As cited in Richard A. Bitzinger, "Arms to Go: Chinese Arms Sales to the Third World," *International Security*, Volume 17, Number 2, Autumn 1992: http://www.jstor.org/stable/2539169

[124] "If Israel Sold Patriot Secrets…" *New York Times*, March 20, 1992: http://www.nytimes.com/1992/03/20/opinion/if-israel-sold-patriot-secrets.html. See also Richard A. Bitzinger, "Arms to Go: Chinese Arms Sales to the Third World," *International Security*, Volume 17, Number 2, Autumn 1992: http://www.jstor.org/stable/2539169

[125] "PiLi-8 Short-Range Air-to-Air Missile," SinoDefence.com, October 12, 2008: http://www.sinodefence.com/airforce/weapon/pl8.asp

[126] David B. Ottaway, "Israelis Aided China on Missiles: Weapons for Saudis Improved Despite Potential Threat," *Washington Post*, May 23, 1988.

[127] Jim Mann, "Threat to Mideast Military Balance; U.S. Caught Napping by Sino-Saudi Missile Deal," *Los Angeles Times*, May 4, 1988.

[128] Bates Gill and Taeho Kim, *China's Arms Acquisitions from Abroad: A Quest for "Superb and Secret Weapons,"* New York: Oxford University Press, 1995. p. 85.

the $1 billion deal would compromise U.S. national security, Israel withdrew from the agreement in 2000, forcing China to embark on an indigenous AWACS platform.[129] Subsequent technology transfers have generated additional scrutiny, among them a deal—scrapped in 2005—in which Israel agreed to provide spare parts to China's fleet of Harpy anti-radar drones, which had been purchased from Israel in the mid-1990s. Taiwanese officials objected that the unmanned aircraft would degrade Taiwan's defenses in a military confrontation with the PRC. U.S. Undersecretary of Defense for Policy Douglas J. Feith was reported to have been so angered by the sale that he demanded the resignation of Amos Yaron, the head of Israel's Ministry of Defense.[130] Partly in retaliation for the Harpy sale and also as a result of concern over future compromises of sensitive technology, the United States suspended Israel's participation in the F-35 Joint Strike Fighter program.[131] However, a short time later U.S. technology transfers to Israel resumed.[132] Israel withdrew from the Harpy arrangement and pledged to submit future weapons sales to China to U.S. scrutiny.[133]

In the wake of the Phalcon and Harpy controversies, the extent of Israel's commercial military interactions with the PRC has become less clear. Both countries have a strong incentive to underplay whatever cooperation exists—or conceal it altogether. For Israel, U.S. economic and security assistance is too important to risk alienating the country's principal benefactor; for China, camouflaging the quality of its military capabilities, to say nothing of their source, may help avoid alarming the United States and fueling U.S. military expenditures that China would in turn feel compelled to match. Yet the underpinnings of the original Sino-Israeli relationship—Israel's economic reliance on defense exports and China's eagerness to acquire advanced military technology—remain unchanged. This continuity of motive suggests that any meaningful cooperation between the two countries will occur beyond the gaze of public scrutiny, thereby increasing analysts' difficulty in assessing developments in the strategic relationship.

[129] Wade Boese, "Israel Halts Chinese Phalcon Deal," *Arms Control Today*, September 2000: http://www.armscontrol.org/act/2000_09/israelsept00

[130] Sudha Ramachandran, "US up in arms over Sino-Israel ties," *Asia Times*, December 21, 2004: http://www.atimes.com/atimes/Middle_East/FL21Ak01.html

[131] Erik Lin-Greenberg, "Offensive Airpower with Chinese Characteristics," *Air & Space Power Journal*, Fall 2007; see also "Israel Frozen out of F-35 Development," *Defense Industry Daily*, April 19, 2005: http://www.defenseindustrydaily.com/2005/04/reports-israel-frozen-out-of-f35-development/index.php

[132] Bill Gertz, "U.S. to restart arms technology transfers to Israel," *Washington Times*, August 17, 2005: http://www.washingtontimes.com/news/2005/aug/17/20050817-121710-1862r/

[133] Scott Wilson, "Israel Set to End China Arms Deal Under U.S. Pressure," *Washington Post*, June 27, 2005: http://www.washingtonpost.com/wp-dyn/content/article/2005/06/26/AR2005062600544.html

SECTION 3: ILLICIT TECHNOLOGY ACQUISITIONS

China's illicit acquisition of advanced technology, whether military, civilian, or dual-use, has been a cornerstone of its effort to "catch up" to the West technologically for decades. Since the 1970s, the PRC has developed a reputation as an aggressive gatherer of export-restricted defense products, sensitive commercial technologies, and foreign military intelligence. This effort has only accelerated in the last decade as the PLA's modernization drive has reached full stride. So aggressive are China's practices in obtaining U.S. high-tech products that the 2007 report of the U.S.-China Economic and Security Review Commission described Chinese espionage efforts as "the single greatest risk to the security of American technologies."[134]

China's efforts to acquire advanced technology illicitly can generally be divided into two broad categories. The first consists of espionage, both in its traditional form, where intelligence and military organs clandestinely steal national security secrets, and its industrial variant, where the aim is to acquire commercial secrets and the range of actors is broadened to include scientific and manufacturing entities. The second includes collusion with legitimate suppliers who violate their national export laws, as well as illegitimate suppliers trading on the black market.[135]

3.1 Key Players

The PRC's two principal intelligence organs are its Ministry of State Security (MSS), often referred to as "China's CIA," and the Military Intelligence Department of the PLA General Staff (MID/PLA).[136] Formed in 1983, the MSS is China's largest foreign intelligence service, although its portfolio also includes counterintelligence and domestic security matters such as monitoring political dissident activity.[137] The MID/PLA, sometimes referred to as the Second Department, maintains two bureaus whose operations are relevant to acquiring advanced technology from abroad. The first is the Western Nations Analysis Bureau, which collects information from open-sources, including foreign scientific literature.[138] The second is the Bureau of Science and Technology, which houses China's extensive cyber intelligence apparatus. (See subsection 3.2.8 Cyber Exploitation below for a more detailed description of China's cyber espionage activities).

One distinctive feature of Chinese technology acquisition is the autonomy given to research institutes, corporations, and other entities to devise collection schemes according to their particular needs. These operations, which often involve surreptitious means of obtaining information, occur outside the direct supervision of the state's intelligence apparatus.[139] James Mulvenon cautions against a monolithic view of Chinese intelligence gathering. Instead, among Chinese consumers of intelligence there exists "bitter

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134 *2007 Report to Congress of the U.S.-China Economic and Security Review Commission,* November 2007: http://www.uscc.gov/annual_report/2007/report_to_congress.pdf
135 Ariana Eunjung Cha, "Even Spies Embrace China's Free Market," *Washington Post*, February 15, 2008: http://www.washingtonpost.com/wp-dyn/content/article/2008/02/14/AR2008021403550.html
136 Nicholas Eftimiades, Testimony before the Joint Economic Committee, U.S. Congress, May 20, 1998: http://www.house.gov/jec/hearings/intell/eftimiad.htm
137 *Intelligence Threat Handbook*, Interagency OPSEC Support Staff, June 2004: http://fas.org/irp/threat/handbook/index.html
138 Ibid.
139 *Intelligence Threat Handbook*, 2004.

rivalry…multiple redundant tasking, [and] individuals and companies being tasked to compete with one another to acquire the same technology."[140]

3.2 PRC Intelligence Gathering Methodologies

The following section describes the various PRC intelligence gathering methodologies used to acquire advanced technology for both military and commercial purposes. In addition to describing particular approaches, the section provides a number of anecdotes to illustrate the unique characteristics of Chinese espionage. These include China's emphasis on "actuarial" intelligence, or the aggregation of information from diffuse sources; ethnic targeting of "overseas Chinese," including Chinese-Americans working in the high-tech field, and the collection of information by Chinese research institutes and commercial enterprises that act independently of the PRC intelligence services.

3.2.1 Actuarial Intelligence

According to numerous analyses of Chinese espionage methods, the PRC approaches intelligence gathering rather differently than the "classical" spying operations of the major powers—that is, the intelligence practices that emerged during the World War II and the Cold War. These spy services have traditionally relied on a small number of highly valuable "moles" within targeted institutions such as foreign intelligence agencies and military services. By contrast, China is frequently described as collecting small amounts of information from a wide variety of sources using methods that have been characterized as "low-key and non-threatening."[141] Paul Moore, former FBI chief analyst for PRC intelligence, provides a simple analogy to contrast the Chinese approach to information gathering, which he terms "actuarial" intelligence, with traditional Western methods:

> If the composition of the sand on a certain beach were identified as an intelligence target by the nations of the world, some countries would solve the challenge by dispatching a submarine to sit offshore from the beach. In the dark of night, a commando team would emerge from the submarine, paddle in a rubber raft to the beach, scoop up a bucket or two of sand, and beat a retreat back to the submarine. Analysis of the buckets of sand would produce a great deal of data. Other countries would task their satellites flying overhead to turn their sophisticated infrared and spectrographic scanners on the beach, and this also would produce a wealth of data. China, however, would approach the problem by allowing ten thousand of its citizens to spend the day at the beach. At sunset they all would go home and simply shake out their towels; and the Chinese would end up with more sand—and more data—than the other nations.[142]

Non-professional Chinese intelligence assets may include students living or traveling abroad, scientists, businesspeople, and members of the Chinese diaspora community, or "overseas Chinese." Collectively, these groups represent what one former U.S. counterintelligence official described as "multiple redundant collection platforms."[143] "Credentialed" intelligence agents often assist these individuals' activities, especially by transmitting the needs of Chinese military enterprises, corporations, and research institutes to assets who may be in a position to help them. However, most of these collectors of information, and especially Chinese Americans who transfer information to the PRC, cannot be

[140] James Mulvenon, testimony before the U.S.-China Economic and Security Review Commission hearing on "China's Propaganda and influence Operations, Its intelligence Activities that Target the United States, and the Resulting Impacts on U.S. National Security," April 30, 2009: http://www.uscc.gov/hearings/2009hearings/transcripts/09_04_30_trans/09_04_30_trans.pdf

[141] *Report to Congress on Chinese Espionage Activities Against the United States*, CIA/ FBI Report, December 12, 1999: http://www.fas.org/irp/threat/fis/prc_1999.html

[142] Paul Douglas Moore, "Chinese Culture and the Practice of 'Actuarial' Intelligence," Federal Bureau of Investigation, U.S. Department of Justice (undated): http://www.asiancrime.org/pdfdocs/Actuarial_Intelligence_by_Paul_Moore.pdf

[143] Neil A. Lewis, "Spy Cases Raise Concern on China's Intentions," *New York Times*, July 10, 2008: http://www.nytimes.com/2008/07/10/washington/10spy.html

considered intelligence operatives in any real sense. Instead, many are everyday professionals with access to advanced technology whose ancestry is played upon to elicit cooperation.[144]

3.2.2 **Ethnic Targeting: Exploiting Volunteerism of Nonprofessional Gatherers**

A joint CIA/FBI report on China's espionage against the United States issued in 1999 described "a network of nonprofessional individuals and organizations acting outside the direction and control of [China's] intelligence services" seeking to "collect information, either formally for those services or informally for their home-based research institutes or universities."

Chinese intelligence services, as well as commercial and scientific enterprises seeking U.S. technology, often use appeals to Chinese Americans' residual patriotism toward China as the principal motivation to provide sensitive information. Though the Chinese compensate providers of information, most of the individuals charged with espionage on behalf of the PRC have not exhibited behavior such as drug, gambling, or sexual addiction that make them vulnerable to monetary enticement, a common practice during the Cold War.[145] Nor have most been the victims of bald coercion such as blackmail. (However, the case of Katrina Leung, who is widely suspected of having been a double agent for China's MSS, did feature a romantic relationship with her intelligence target. Leung, a Los Angeles-based FBI informant, engaged in affairs with two FBI Special Agents, James Smith and William Cleveland, the former of which gave her access to substantial quantities of classified information. Leung pleaded guilty to two minor charges; the more serious case against her was dismissed for prosecutorial misconduct.[146])

According to the *Intelligence Threat Handbook*, "ethnic targeting to arouse feelings of obligation [to China] is the single most distinctive feature of PRC intelligence operations." In these operations, the recruitment pitch is "not an appeal to ethnicity per se, but to whatever feelings of obligation the targeted individual may have towards China, family members in China, old friends in China, etc."[147] Paul Moore describes profiling of Americans based on ethnic background as "the mainstay of [China's] intelligence effort against the United States." Describing the typical Chinese approach, Moore suggests that Chinese intelligence gatherers "find a facility of interest [sic] they walk in and they look around and they say, nice facility, is there anybody here who is Chinese, ethnic Chinese?" Approached individuals are then pressured to provide assistance to their "ancestral land."[148]

The U.S. intelligence community estimates that "ethnic targeting" is so pervasive that it accounts for 98 percent of MSS recruitment efforts.[149] A 2008 DoD-sponsored study of espionage committed by U.S. citizens found that while less than 10 percent of Americans acting as spies before 1990 had cultural ties to foreign nations, the percentage with foreign links had increased to 50 percent by 2007. Similarly, while "divided loyalty" was considered the primary motivation in fewer than 20 percent of cases before 1990, since then this motive has factored in 57 percent of espionage cases.[150] One possible explanation

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[144] Peter Grier, "Spy case patterns the Chinese style of espionage," *Christian Science Monitor*, November 30, 2005: http://www.csmonitor.com/2005/1130/p01s01-usfp.html
[145] Stéphane Lefebvre, "The PRC's Compromise of U.S. Government Information and Technologies," *International Journal of Intelligence and CounterIntelligence*, Volume 22, Issue 4, December 2009.
[146] Sonya Geis, "FBI Officials Are Faulted In Chinese Spying Case," *Washington Post*, May 25, 2006: http://www.washingtonpost.com/wp-dyn/content/article/2006/05/24/AR2006052402386.html
[147] *Intelligence Threat Handbook,* Interagency OPSEC Support Staff, June 2004: http://fas.org/irp/threat/handbook/index.html
[148] "Biased Prosecution?" PBS NewsHour with Jim Lehrer transcript, December 14, 1999 http://www.pbs.org/newshour/bb/law/july-dec99/wenholee_12-14.html
[149] *Intelligence Threat Handbook,* Interagency OPSEC Support Staff, June 2004: http://fas.org/irp/threat/handbook/index.html
[150] Katherine L. Herbig, "Changes in Espionage by Americans: 1947-2007," Northrop Grumman Technical Services (Sponsoring organization: Defense Personnel Security Research Center, Technical Report 08-05), March 2008: http://www.fas.org/sgp/library/changes.pdf

for this phenomenon is the substantial increase in the number of foreign-born Americans in recent decades and a corresponding increase in the number of persons with foreign ties who are granted security clearances.

In some instances, contact with Chinese consumers of intelligence, either in the PRC intelligence services or scientific institutions, is first initiated by Chinese Americans themselves acting out of a sense of obligation to their native country. In the late 1970s, PRC-born naturalized U.S. citizen Dongfan "Greg" Chung, who worked as an engineer for defense contractors Rockwell International and Boeing, composed a letter to a Chinese technology institute stating his desire to "make an effort to contribute to the Four Modernizations of China."[151] Replying to Dongfan, Professor Chen Lung Ku of the PRC's Harbin Institute of Technology wrote that he and his colleagues were moved by Dongfan's patriotism, adding that they would like to "join our hands together with the overseas compatriots in the endeavor for the construction of our great socialist motherland."[152] In another letter dated 1987 that was discovered during a search of his home, a Chinese official praised Dongfan, along with Chi Mak, another Chinese American engineer convicted of spying, stating that it was "China's fortune that you are able to realize your wish of dedicating yourselves to the services of your country." Dongfan was suspected of providing to China information relating to a phased-array antenna for the Space Shuttle, as well as a fueling mechanism for the Delta IV space launch rocket.[153] Convicted in 2009 for conspiracy, economic espionage, acting as a foreign agent, and making false statements to federal investigators,[154] Dongfan was sentenced to more than 15 years in prison.[155]

Another case involves Peter H. Lee, a Chinese American physicist who became a naturalized citizen in 1975. In 1981, Lee began to communicate with scientists in China through letters and email, a correspondence that would ultimately produce more than 600 messages by the time of his arrest in 1997.[156] By virtue of his employment at Los Alamos National Laboratory, Lee had access to sensitive nuclear weapons-related information, which he divulged during a 1985 visit to Beijing.[157] On this occasion, Lee was approached in his hotel room by a Chinese nuclear scientist representing the China Academy of Engineering Physics (CAEP), who asked for Lee's help in assisting his "poor country." Lee complied, answering detailed questions.[158] The following day, Lee was escorted to another meeting with Chinese scientists, who peppered him with questions for two hours and in return received diagrams and experimental results concerning laser fusion research.[159] Prosecutors later described the information passed at this meeting as having "important military applications related to nuclear weapons," though it was declassified in 1993.[160] During a subsequent visit to the PRC in 1997 paid for by China's Institute of Applied Physics and Computational Mathematics (IAPCM), Lee twice delivered a two-hour lecture concerning satellite-enabled submarine tracking under development by his then employer, defense

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151 The "Four Modernizations" introduced by Deng Xiaoping in 1975 were: agriculture, industry, science and technology, and national defense. See Immanuel C.Y. Hsü, *The Rise of Modern China*, New York: Oxford University Press, 2000.

152 Scott Shane, "A Spy's Motivation: For Love of Another Country," *New York Times*, April 20, 2008: http://www.nytimes.com/2008/04/20/weekinreview/20shane.html

153 Gillian Flaccus, "Dongfan 'Greg' Chung, Chinese Spy, Gets More Than 15 Years In Prison," Associated Press, February 8, 2010: http://www.huffingtonpost.com/2010/02/08/dongfan-greg-chung-chines_n_454107.html

154 Edvard Pettersson, "Ex-Boeing Engineer Chung Guilty of Stealing Secrets," *Bloomberg News*, July 16, 2009: http://www.bloomberg.com/apps/news?pid=20601087&sid=aCeCvWPvvEdM

155 Gillian Flaccus, op. cit.

156 James Brooke, "An Earlier China Spy Case Points Up Post-Cold War Ambiguities," *New York Times*, March 13, 1999.

157 William Claiborne, "Taiwan-Born Scientist Passed Defense Data; Ex-Los Alamos Worker Gave Secrets to China," *Washington Post*, December 12, 1997.

158 "Report on the Investigation of Peter Lee," Report of the Senate Judiciary Subcommittee on Department of Justice Oversight, December 20, 2001: http://www.fas.org/irp/congress/2001_rpt/peterlee.html

159 Jeff Gerth and James Risen, "Reports Show Scientist Gave U.S. Radar Secrets to Chinese," *New York Times*, May 10, 1999.

160 Claiborne, op. cit.

contractor TRW, Inc. Lee avoided an espionage charge for the latter incident in part because Navy officials were reluctant to permit testimony concerning the technology in open court; instead Lee pleaded guilty to filing a false statement regarding his trip to China as well as to revealing secrets during his 1985 visit.[161]

Perhaps the most well-known instance of alleged Chinese espionage against the United States is the case of former Los Alamos National Laboratory scientist Wen Ho Lee, who was suspected of passing nuclear weapons data to the PRC over the course of two decades. Lee, a Taiwanese American, was indicted in 1999 on 59 criminal counts—though never charged with espionage—and ultimately pleaded guilty to a single count of mishandling classified material. The remaining 58 charges against him were dismissed.[162] Lee later received a $1.6 million settlement from the U.S. government and several media organizations for improper conduct in his case, as well as an apology from the presiding federal judge, who characterized Lee's prosecutors of having "embarrassed our entire nation."[163] Lee eventually emerged as a largely sympathetic figure in media portrayals despite a pattern of highly suspicious activity that has never been convincingly explained. These activities included downloading enormous quantities of classified nuclear weapons data from the Los Alamos computer system, removing classification headers, and copying the data to an unclassified network; failing to report contact with foreign individuals seeking classified information; and using a colleague's computer to transfer classified data to an unclassified network after Lee's own security clearance had been revoked.

In light of the persistence of espionage cases involving Chinese Americans, a perception appears to have formed among many U.S. counterintelligence personnel that such individuals are deserving of greater scrutiny than Americans who lack foreign ties. Naturally, even the most fair-minded observation of a potential security liability stemming from an American's ethnic background is highly controversial. Indeed, the Wen Ho Lee case was thoroughly colored by suggestions that race had suffused the broader investigation of Chinese espionage against U.S. nuclear facilities. Robert Vrooman, former chief of counterintelligence at Los Alamos, testified before a 2002 Senate hearing that investigators searching for a spy in the U.S. nuclear weapons establishment "had a subtle bias that the perpetrator had to be ethnic Chinese."[164] Notra Trulock, former head of DOE intelligence and a central figure in the Lee case, has alleged that DOE officials once attempted to create a database containing the ethnic background of Americans with access to sensitive nuclear weapons information.[165] PRC intelligence services are doubtless aware of this increased sensitivity, and they may have reacted accordingly by decreasing their reliance on ethnic Chinese. However, no evidence in the open literature offers insight into Chinese operational responses to these developments.

Another potential source of sensitive information is the pool of Chinese "specialty workers" who hold H1-B visas—temporary allowances to work in the United States in highly specialized fields. In 2003, there were roughly 27,000 such individuals residing in the country, most of whom returned to China within a specified period of time.[166] Numerous reports have also documented the PRC's use of Chinese

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161 Gerth and Risen, op. cit.

162 James Risen, "Officials Disagree on How Lab Scientist Became Spy Suspect," *New York Times*, October 4, 2000: http://www.nytimes.com/2000/10/04/us/officials-disagree-on-how-lab-scientist-became-spy-suspect.html

163 Paul Farhi, "U.S., Media Settle With Wen Ho Lee," *Washington Post*, June 3, 2006: http://www.washingtonpost.com/wp-dyn/content/article/2006/06/02/AR2006060201060.html

164 "Continuation of Oversight of the Wen Ho Lee Case," Hearing before the Senate Committee on the Judiciary, October 3, 2000: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=106_senate_hearings&docid=f:74193.pdf

165 James Risen, "Officials Disagree on How Lab Scientist Became Spy Suspect," *New York Times*, October 4, 2000: http://www.nytimes.com/2000/10/04/us/officials-disagree-on-how-lab-scientist-became-spy-suspect.html

166 Larry M. Wortzel, "Sources and Methods of Foreign Nationals Engaged in Economic and Military Espionage," Heritage Lecture #907, November 4, 2005: http://www.heritage.org/Research/AsiaandthePacific/hl907.cfm

citizens studying in the United States—numbering almost 100,000 today[167]—as collectors of intelligence. Richard Suttmeier suggests that access to the U.S. university system among Chinese students has made this source of knowledge "one of the most valuable assets in the international environment to be exploited by China," although presumably only a small fraction of these individuals are professional intelligence agents.[168] Many PRC nationals are enrolled in American graduate schools, where their study of the hard sciences is considered, according to one CIA/ FBI Report, as being "of value to China's efforts to ascend the technology ladder."[169] As a result of the sheer number of Chinese nationals studying or working in the United States, the PRC maintains an intelligence advantage that is arguably without precedent in the history of modern espionage—China's defense and intelligence agencies enjoy access to American research institutes, laboratories, and industrial facilities that perhaps no other country, friendly or hostile, has ever achieved.[170]

In some cases, the lax security standards of American research institutes afford Chinese students access to sensitive defense technology that would be more difficult to acquire from the national laboratories, defense contractors, or military end-users. A 2008 incident at the University of Tennessee is illustrative of this point. In this case, a Chinese graduate student, Xin Dai, was improperly allowed to participate in research for the U.S. Air Force involving unmanned aerial vehicles.[171] While the research was unclassified, it concerned sensitive export-controlled technology. No connection was ever established between Xin and handlers in the PRC, nor was he determined to have transferred technology. Nevertheless, J. Reece Roth, professor emeritus of electrical and computer engineering, was sentenced to four years imprisonment for violating the Arms Export Control Act by involving Xin and another foreign student in the research.[172]

3.2.3 **Entrepreneurial Intelligence Gatherers**

In a 2007 speech, former NCIX Joel F. Brenner spoke of a "seismic shift toward increasing reliance on the private sector in the intelligence world."[173] Several cases of economic espionage suggest that thieves of U.S. technology are often not credentialed PRC agents but rather profit-seekers seeking to sell sensitive American technologies and products to China.[174] Nevertheless, U.S. officials hold the PRC responsible for encouraging such practices, in part by exploiting the technologies China obtains through unscrupulous means.

One such instance involves Ko-suen "Bill" Moo, a Korean-born Taiwanese arms broker for Lockheed Martin, who was convicted of attempting to buy an F-16 fighter turbofan engine in the United States for $3.9 million and ship it to China's Shenyang Aircraft Corporation. Incredibly, during negotiations with

[167] Tamar Lewin, "China Is Sending More Students to U.S.," *New York Times*, November 16, 2009: http://www.nytimes.com/2009/11/16/education/16international-.html

[168] Richard P. Suttmeier, "From Cold War Science Diplomacy to Partnering in a Networked World: 30 Years of Sino-US Relations in Science and Technology," Earlier version presented at the 2009 Hixon Forum on "Science and Technology in the Making of Modern China," February 27-28, 2009: http://china-us.uoregon.edu/pdf/030409.pdf

[169] *Report to Congress on Chinese Espionage Activities Against the United States*, CIA/ FBI Report, December 12, 1999.

[170] Dan Verton, "The Evolution of Espionage: Beijing's Red Spider Web," *China Brief*, Volume 8, Issue 15, July 17, 2008: http://www.jamestown.org/programs/chinabrief/single/?tx_ttnews[tt_news]=5060&tx_ttnews[backPid]=168&no_cache=1

[171] Josh Gerstein, "Chinese Grad Student's Work Leads to Criminal Case," *New York Sun*, April 17, 2008: http://www.nysun.com/national/chinese-grad-students-work-leads-to-criminal-case/74830/

[172] "Ex-prof gets 4 years for passing military secrets," Associated Press, July 1, 2009.

[173] Joel F. Brenner, "Welcoming Remarks—DNI's Private Sector Symposium on Insider Threats," Carnegie Endowment for International Peace, May 30, 2007: http://www.ncix.gov/publications/speeches/WELCOMING_REMARKS.pdf

[174] Ariana Eunjung Cha, "Even Spies Embrace China's Free Market," *Washington Post*, February 15, 2008: http://www.washingtonpost.com/wp-dyn/content/article/2008/02/14/AR2008021403550.html

U.S. undercover agents, Moo expressed interest in purchasing a complete F-16 fighter aircraft.[175] Following a guilty plea, he was sentenced to six years imprisonment in 2006. Moo's case resembles that of Kwonhwan Park, a South Korean businessman who was sentenced to federal prison in 2005 for arranging the shipment of Black Hawk helicopter engines and night vision technology to China. Both Park and Moo appear to have been freelance businessmen motivated by profit rather than allegiance to the PRC. Whether the illegal sales the men brokered were sanctioned by China's intelligence services is unknown, but some observers have speculated that the operations were conceived independently by the institutions that would benefit from the technology.

In 2008, two Chinese American engineers previously employed in Silicon Valley—Fei Ye and Ming Zhong—were sentenced to prison for violations of the Economic Espionage Act. The men were arrested as they attempted to fly to China with microchip designs stolen from Sun Microsystems and other prior U.S. employers. Official PRC collusion in the conspiracy was not demonstrated, though the two men acknowledged that a company they had established to exploit the stolen technology, Supervision, Inc., was slated to share profits with the City of Hangzhou and Zhejiang province in China; they also admitted to having sought funding from China's 863 Program.[176] (For a more detailed description of the 863 Program, see Section 5: Indigenous Research and Development). In June 2008, Chinese national Xiaodong Sheldon Meng was sentenced to two years in federal prison for the theft of a visual simulation training program—software with military aviation applications—and other defense-related products from Quantum3D, a Silicon Valley defense contractor.[177] Xiaodong had attempted to sell the technology to the Thai and Malaysian militaries in addition to the Chinese Navy, suggesting that he was not acting exclusively on behalf of the PRC.[178] U.S. prosecutors acknowledge that Xiaodong's crimes were rooted in monetary gain rather than foreign allegiance and that Chinese officials were evidently unaware that the items offered to them had been illegally obtained.[179]

While the PRC's reliance on Chinese Americans for espionage is persistent, necessity requires that its intelligence services take an ecumenical approach to acquiring sensitive information. Accordingly, Chinese intelligence gatherers attempt to extract secrets from whomever possesses them. Such individuals often have no outward sympathies toward China but instead provide information as a result of inducements ranging from trickery to financial remuneration. The case of former Northrop Grumman scientist Noshir Gowadia is typical. Gowadia, who is currently awaiting trial on federal espionage charges, was intimately involved in the development of the B-2 Spirit bomber's stealth technology.[180] In an arrangement with the PRC worth an estimated $2 million, Gowadia is accused of designing a cruise missile exhaust system nozzle that decreased the missile's susceptibility to detection and interception.[181] He is reported to have traveled to China at least six times between 2003 and 2005 to

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[175] Simon Cooper, "How China Steals U.S. Military Secrets," *Popular Mechanics*, August 2006: http://www.popularmechanics.com/technology/military_law/3319656.html?page=1

[176] "Two Men Plead Guilty to Stealing Trade Secrets from Silicon Valley Companies to Benefit China." U.S. Department of Justice press release, December 14, 2006: http://www.justice.gov/criminal/cybercrime/yePlea.htm

[177] John Coté, "Salesman sentenced to 2 years in prison as industrial spy, thief," *The San Francisco Chronicle*, June 19, 2008.

[178] "Former Chinese National Charged with Stealing Military Application Trade Secrets from Silicon Valley Firm to Benefit Governments of Thailand, Malaysia, and China," U.S. Department of Justice press release, December 14, 2006: http://www.justice.gov/criminal/cybercrime/mengCharge.htm

[179] Jordan Robertson, "Engineer is first sentenced for economic espionage," Associated Press, June 18, 2008.

[180] Second Superseding Indictment of Noshir S. Gowadia, *United States of America vs. Noshir S. Gowadia*, October 27, 2007: http://www.fas.org/irp/ops/ci/gowadia.pdf

[181] "Hawaii Man Indicted for Selling National Defense Secrets to the People's Republic of China," U.S. Attorney Edward H. Kubo, U.S. Department of Justice press release, November 9, 2006: http://web.archive.org/web/20070523175209/http://honolulu.fbi.gov/dojpressrel/pressrel06/defensesecrets110906.htm

participate personally in the test and evaluation of his cruise missile design.[182] Notably, the PRC was one of four countries, including Switzerland, Germany, and Israel, to which Gowadia peddled restricted information, which may suggest that China did not specifically target the scientist for the expertise he possessed but instead took advantage of an opportunity to acquire advanced technology, albeit illegally.

A 1999 report by the President's Foreign Intelligence Advisory Board (PFIAB) concerning the espionage threat to the Department of Energy's (DOE) weapons labs characterized Chinese intelligence gatherers as "very proficient in the art of seemingly innocuous elicitations of information. This modus operandi has proved very effective against unwitting and ill–prepared DOE personnel."[183] One creative method of harvesting information from foreign visitors to China is colorfully described in the *Intelligence Threat Handbook*:

> Intelligence is obtained from unwitting sources…by maneuvering the individual into a social or professional situation in which he can be embarrassed or cajoled into providing at least a little extra information. The actual elicitation in China is done by Chinese intelligence "consumers" themselves, although intelligence officers may have a role in manipulating a targeted individual into a situation where he is at a disadvantage. For example, it is not uncommon for the Chinese to arrange for a target visitor to go on an all-day sightseeing excursion, after which they will throw a cocktail party in his honor, toast him with potent Chinese liquor as much as possible, and then surround him with a small group of questioners asking about sensitive topics. Under the strain of fatigue, alcohol, and group pressure, some U.S. visitors have made indiscreet statements or unauthorized disclosures.[184]

The suggestion that Chinese operatives excel at eliciting classified information through trickery was central to the defense of former Defense Intelligence Agency (DIA) China specialist Ronald Montaperto, who pleaded guilty in 2006 to unlawful retention of classified documents. Montaperto admitted to passing secrets to China over a 14-year period, often through in-person conversations with two Chinese officials, Colonel Yang Qiming and Colonel Yu Zhenghe, who were intelligence operatives acting as PLA military attachés.[185] Montaperto claimed to have divulged classified information as a result of manipulation by his Chinese counterparts.[186] He received a mere three months' confinement, largely as a result of support from intelligence community colleagues who viewed his actions more benignly than the charges against him would suggest.[187]

3.2.4 **Moles**

While non-professional intelligence gatherers are commonly used to acquire sensitive U.S. technology, the PRC does not rely exclusively on sympathizers recruited in the United States. Several instances reveal the methodical placement of individuals as "moles" within the U.S. government and commercial sectors. Such is the case of Larry Wu-tai Chin, a U.S. government employee for more than three

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[182] Jason Ryan, "Former B-2 Bomber Engineer Accused of More Spying," ABC News, November 10, 2006: http://abcnews.go.com/Technology/story?id=2645205&page=1

[183] "Science at its Best, Security at its Worst: A Report on Security Problems at the U.S. Department of Energy," A Special Investigative Panel of the President's Foreign Intelligence Advisory Board, June 1999: http://www.loyola.edu/departments/academics/political-science/strategic-intelligence/intel/pfiab_doe_report.pdf

[184] *Intelligence Threat Handbook*, Interagency OPSEC Support Staff, June 2004: http://fas.org/irp/threat/handbook/index.html

[185] Bill Gertz, "Ex-DIA analyst admits passing secrets to China," *Washington Times*, June 23, 2006: http://www.washingtontimes.com/news/2006/jun/23/20060623-120347-7268r/

[186] Matthew Barakat, "Disclosures to Chinese gets man three months in jail," Associated Press, September 9, 2006.

[187] Bill Gertz, "Inside the Ring," *Washington Times*, February 23, 2007. Other U.S. officials bristle at the suggestion that Montaperto's actions were innocuous. David Szady, former FBI counterintelligence director, described Montaperto as "guilty as hell" and insisted, "If he had it, they got it." See Bill Gertz, "Friends rallying to defend DIA spy; Call data given to China minor," *Washington Times*, July 5, 2006.

decades, first serving as an interpreter for the U.S. Army Liaison Office during World War II and later as a translator for the CIA's Foreign Broadcast Information Service. Born in Beijing, Chin is believed to have been tasked by Chinese intelligence with entering U.S. service for the explicit purpose of becoming a mole. Convicted of spying in 1985, Chin committed suicide before his sentencing.[188] Another example is Bin Wu, a former philosophy professor in China who moved to the United States in 1990, apparently on orders from the MSS to establish himself as a businessman and gain access to military hardware.[189] Bin was convicted in 1992 of passing restricted night vision technology to China.[190]
Chi Mak, a naturalized American citizen who worked as an engineer for L-3 Communications subsidiary Power Paragon, was described by his prosecutors as a classic "sleeper agent."[191] Chi was said to have been directed to burrow deeply into the U.S. defense establishment to provide sensitive information over a long period of time.[192] Investigators reportedly found shredded instructions from PRC handlers in Chi's home beseeching him to join "more professional associations and participate in more seminars with 'special subject matters' and to compile special conference materials on disk."[193] Many of the technologies Chi was convicted of providing concerned advanced naval capabilities, including information relating to the U.S. Navy's next generation (DDX) warship and Quiet Electric Drive (QED) technology.[194] In a 2008 interview, Joel F. Brenner, the former National Counterintelligence Executive (NCIX), suggested that China's military intelligence gathering operations against the United States are directed heavily toward acquiring naval technologies to increase its advantage in a Taiwan Strait conflict.[195] Chi was sentenced to 24 years in federal prison in 2008.

3.2.5 **Front Companies**

Among the more persistent allegations of Chinese commercial espionage in the United States involves the use of "front" companies—intelligence and technology gathering operations masquerading as legitimate businesses. Reports of such companies run either by the PLA or PRC intelligence services date back more than a decade. For example the 1999 *Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China*, otherwise known as the Cox Report, placed the number of PRC front companies in the United States at "more than 3,000" and suggested that some of these had "links to the PLA, a State intelligence service, or…technology targeting and acquisition roles."[196] However, as one analysis of this figure concluded, the assumption that thousands of state-directed Chinese commercial entities could be operating clandestinely in the United States rested on "lumping together civilian, military and defense-industrial companies incorporated in the U.S.," not

[188] "Four Chinese Espionage Investigations," PBS Frontline special "From China With Love," January 15, 2004: http://www.pbs.org/wgbh/pages/frontline/shows/spy/spies/four.html
[189] Dan Verton, "The Evolution of Espionage: Beijing's Red Spider Web," *China Brief*, Volume 8, Issue 15, July 17, 2008: http://www.jamestown.org/programs/chinabrief/single/?tx_ttnews[tt_news]=5060&tx_ttnews[backPid]=168&no_cache=1
[190] William Glaberson, "Spy, Citing Fears, Fights Return to China," *New York Times*, December 3, 2001: http://www.nytimes.com/2001/12/03/us/spy-citing-fears-fights-return-to-china.html?pagewanted=1
[191] Joby Warrick and Carrie Johnson, "Chinese Spy 'Slept' In U.S. for 2 Decades," *Washington Post*, April 3, 2008: http://www.washingtonpost.com/wp-dyn/content/story/2008/04/02/ST2008040204050.html
[192] This characterization is not universally shared. Retired FBI agent I.C. Smith has testified that "government and media assertions that [Chi Mak] was a long-time intelligence operative are less than clear to me." See I.C. Smith, testimony before the U.S.-China Economic and Security Review Commission, April 30, 2009.
[193] Larry M. Wortzel, testimony before the House Judiciary Subcommittee on Crime, Terrorism, and Homeland Security, hearing on "Enforcement of Federal Espionage Laws," January 29, 2008: http://judiciary.house.gov/hearings/pdf/Wortzel080129.pdf
[194] Joel F. Brenner, "Intelligence, Thinking, and Academia," Intelligence Community Centers of Academic Excellence Summer Seminar, July 24, 2007: http://www.ncix.gov/publications/speeches/SummerSeminar.pdf
[195] Neil A. Lewis, "Spy Cases Raise Concern on China's Intentions," *New York Times*, July 10, 2008: http://www.nytimes.com/2008/07/10/washington/10spy.html
[196] *Report of the Select Committee on U.S. National Security and Military / Commercial Concerns with the People's Republic of China*, U.S. House of Representatives, January 3, 1999: http://www.house.gov/coxreport/. p. 34.

all of which can be assumed to be "under the thumb of Chinese military or espionage agencies."[197] Perhaps through incorrect interpretations of this number, various permutations of the "3,000 front companies" figure have appeared widely in official statements ever since. For example, in 2005 remarks before a conference on counterintelligence, Lisa Bronson, then Deputy Under Secretary of Defense for Technology Security Policy and Counterproliferation, suggested that China maintains "somewhere between 2,000 and 3,000 front companies in the U.S., and their sole reason for existing is to steal, exploit U.S. technology."[198] The FBI's former Deputy Director for Counterintelligence later nudged the number of such companies upward to over 3,200.[199]

3.2.6 **"False Flag" Operations**

One case that combines two traditional pillars of espionage—deception and bribery—involves Tai Shen Kuo, a Taiwanese American acting on behalf of China. With family and business connections in mainland China, Kuo manipulated two Americans—James Fondren, former deputy director of the Pacific Command's (PACOM) Washington liaison office, and Gregg W. Bergersen, head of C4ISR programs at the Defense Security Cooperation Agency's Weapons Division—in what officials describe as a classic "false flag" operation. Under such cases, an operative poses as the agent of one country, often an ally of the target state, while secretly acting on behalf of another. Kuo succeeded in convincing Fondren and Bergersen that the classified information they were providing was destined for Taiwan rather than the PRC, a subterfuge presumably designed to allow the men to rationalize their misdeeds.[200] The information Fondren and Bergensen passed to Kuo, judged to be of relatively low-level classification, concerned U.S. arms sales to Taiwan.[201] Both convicted of espionage, Bergersen was sentenced to 57 months in prison while Fondren received three years;[202] Kuo received 15 years.[203]

3.2.7 **Transactions with Unscrupulous Arms Dealers**

Beyond the outright theft of advanced weapons and technology, China has also successfully colluded with legitimate suppliers of military technology to violate their own national export laws. For example, in 2007 the U.S. defense contractor ITT Corp. agreed to pay a $100 million fine for illegally exporting night vision technology to buyers in China. (This case also involved shipments to Singapore and the United Kingdom.)[204] Chinese purchasing agents have also arranged illicit deliveries of advanced technologies from a number of countries in addition to the United States.

In March 2005, Ukrainian officials acknowledged that in 2000 China had received six Kh-55 medium-range, air-launched nuclear-capable cruise missiles left over from the Soviet era. However, the

[197] Michael Hiltzik and Lee Romney, "Report's Claim on China 'Front' Firms Disputed," *Los Angeles Times,* May 27, 1999: http://articles.latimes.com/1999/may/27/news/mn-41518

[198] Bill Gertz, "U.S. targets spy services abroad," *Washington Times*, March 5, 2005: http://www.washingtontimes.com/news/2005/mar/05/20050305-111738-8027r/

[199] Larry M. Wortzel, "Sources and Methods of Foreign Nationals Engaged in Economic and Military Espionage," Heritage Lecture #907, November 4, 2005: http://www.heritage.org/Research/AsiaandthePacific/hl907.cfm

[200] Neil A. Lewis, "Spy Cases Raise Concern on China's Intentions," *New York Times*, July 10, 2008: http://www.nytimes.com/2008/07/10/washington/10spy.html

[201] Jerry Markon, "Defense Official Is Charged in Chinese Espionage Case," *Washington Post*, February 12, 2008: http://www.washingtonpost.com/wp-dyn/content/article/2008/02/11/AR2008021101283.html

[202] "Ex-Pentagon official sentenced to 3 years in China spy case," AFP, January 23, 2010: http://sg.news.yahoo.com/afp/20100123/tap-us-china-spy-sentence-8d4ea94.html

[203] Wendell Minnick, "Ex-PACOM Official Convicted of Spying for China," *Defense News*, October 5, 2009: http://www.defensenews.com/story.php?i=4302418

[204] Alec Klein, "ITT to Pay $100 Million Export Fine," *Washington Post*, March 28, 2007: http://www.washingtonpost.com/wp-dyn/content/article/2007/03/27/AR2007032702105.html; see also "Statement of U.S. Attorney John Brownlee on the Guilty Plea of ITT Corporation for Illegally Transferring Classified and Export Controlled Night Vision Technology to Foreign Countries," U.S. Department of Justice, March 27, 2007: http://www.justice.gov/nsd/pdf/itt_statement_by_usattorney.pdf

Ukrainians denied state involvement in the transfer, describing it as a "totally illegal deal carried out by an international criminal group"[205] A 2009 report suggested that China had obtained a prototype of Russia's Sukhoi Su-33 fighter aircraft from the Ukrainian Research Test and Flying Training Center for the purpose of cloning the fighter in support of its carrier-based aviation development program.[206]

3.2.8 **Cyber Exploitation**

While Chinese hackers have breached computer networks in over 100 countries, the United States remains by far the most prominent target of attacks originating in the PRC.[207] Chinese cyber attacks have attempted to penetrate the classified and unclassified computer networks of the Departments of Defense, State, Energy and Homeland Security, and the nation's nuclear weapons laboratories.[208] According to a study for the U.S.-China Economic and Security Review Commission, China is believed to be responsible for conducting a "long term, persistent campaign to collect sensitive but unclassified information from U.S. Government and U.S. defense industry networks using computer network exploitation techniques," an effort that as of 2007 had yielded 10-20 terabytes of data.[209] Additionally, in early 2007, Chinese hackers launched a massive cyber attack on the computers of the German Chancellery and three other government ministries in what was described as an act of economic espionage.[210] Later that year during a trade mission to Beijing, spyware was discovered on several computers and personal communications devices used by then U.S. Secretary of Commerce Carlos M. Gutierrez.[211]

According to numerous anecdotes, U.S. businesspeople and government officials traveling in China have reported attempts to implant monitoring software and remotely steal data from laptop computers. Indeed, a consistent Chinese practice has been observed in which proprietary information is gathered from Western corporations prior to business negotiations in China. Armed with insights into foreign executives' negotiating strategies, a significant advantage accrues to Chinese businesspeople in international deal-making. In a 2008 National Journal report, Brenner recounted an incident in which the sensitive information of "a large American company" was seemingly acquired by Chinese counterparts before a formal negotiation occurred. According to Brenner, "The [U.S.] delegation gets to China and realizes, 'These guys on the other side of the table know every bottom line on every significant negotiating point.'"[212] Additionally, in an incident resembling China's industrial espionage methods, in the summer preceding the 2008 U.S. elections, news reports revealed that computers belonging to the Obama and McCain presidential campaigns had been hacked by an unknown "foreign

[205] David Holley, "China, Iran Missile Sales Confirmed," *Los Angeles Times*, March 19, 2005: http://articles.latimes.com/2005/mar/19/world/fg-missiles19

[206] Wendell Minnick, "Is China Stealing Russia's Su-33?" *Defense News*, May 4, 2009: http://www.defensenews.com/story.php?i=4070484

[207] John Markoff, "Vast Spy System Loots Computers in 103 Countries," *New York Times*, March 29, 2009: http://www.nytimes.com/2009/03/29/technology/29spy.html?pagewanted=print

[208] Markoff, op. cit.; Demetri Sevastopulo, "Chinese hacked into Pentagon," *Financial Times*, September 3 2007: http://www.ft.com/cms/s/0/9dba9ba2-5a3b-11dc-9bcd-0000779fd2ac.html?nclick_check=1; Bradley Graham, "Hackers Attack Via Chinese Web Sites," *Washington Post*, August 25, 2005: http://www.washingtonpost.com/wp-dyn/content/article/2005/08/24/AR2005082402318.html

[209] Bryan Krekel, et al, "Capability of the People's Republic of China to Conduct Cyber Warfare and Computer Network Exploitation," Report prepared for the U.S.-China Economic and Security Review Commission, October 9, 2009: http://www.uscc.gov/researchpapers/2009/NorthropGrumman_PRC_Cyber_Paper_FINAL_Approved%20Report_16Oct2009.pdf

[210] "Chinese Trojan on PCs in the Chancellery," *Der Spiegel*, August 25, 2007: http://www.spiegel.de/netzwelt/tech/0,1518,501954,00.html

[211] Nakashima and Pomfret, op. cit.

[212] Shane Harris, "China's Cyber-Militia," *National Journal*, May 31, 2008: http://www.nationaljournal.com/njmagazine/cs_20080531_6948.php

entity" that was later reported to be China.[213] Speculation on the motive for the breach centered on an attempt to better understand the campaigns' development of policy positions, which might provide advantage in future negotiations with the U.S. administration.[214]

Chinese officials protest that not every act of computer-related espionage or sabotage originating from China is sanctioned by the PRC. Indeed, the authors of a Canadian investigative report on the Chinese malware-based cyber network dubbed *GhostNet* concede that "attributing all Chinese malware to deliberate or targeted intelligence gathering operations by the Chinese state is wrong and misleading." Because China constitutes the world's largest online community, it is "expected that China (and Chinese individuals) will account for a larger proportion of cybercrime."[215] Nevertheless, numerous sophisticated attacks have been observed that strongly indicate PRC involvement. Beginning in August 2006, for example, computers in the offices of two U.S. House members—Representatives Frank Wolf and Christopher Smith—were accessed in what is believed to have been an effort to obtain information on Chinese dissidents; both lawmakers are prominent critics of China's human rights policies.[216]

3.2.9 **Exploitation of Open Sources**

Another method of acquiring foreign technology that is not strictly speaking espionage involves collecting information from scholarly literature and other open sources in the West. This activity long predates China's post-Deng emphasis on developing a broad-based technology infrastructure. Indeed, Chinese physicists utilized open-source literature in their initial development of thermonuclear weapons in the mid-1960s. According to an account by Liu Xiyao, the Vice Minister of the Second Ministry of Machine Building, while China did not enjoy access to secret technical materials relating to hydrogen bomb development, the study of foreign literature "contributed to the unification of our ideas and to the determination of our goals." In particular, the foreign literature brought to their attention the materials needed to produce a thermonuclear reaction.[217] In 1957, the Chinese Academy of Sciences invested a substantial portion of its nuclear weapons budget toward the purchase of Western scientific literature.[218]

A joint CIA/FBI report issued in 1999 on China's espionage against the United States described the activities of military attachés at the Chinese Embassy in Washington, D.C. and the Military Staff Committee at the United Nations, who "openly collect [military] information from Western publications." Other Chinese nationals living abroad, who are usually not in the direct employ of PRC intelligence or military services, "lawfully gather most S&T and economic intelligence through open sources," including university libraries, research facilities, and open-source databases. The information they compile, while unclassified, is nevertheless highly valuable.[219]

In addition, each defense industrial research academy, roughly equivalent to a business division within a major U.S. corporation, has an institute that is responsible for conducting research on foreign technology

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213 Ellen Nakashima and John Pomfret, "China proves to be an aggressive foe in cyberspace," *Washington Post*, November 11, 2009: http://www.washingtonpost.com/wp-dyn/content/article/2009/11/10/AR2009111017588.html

214 "Hackers and Spending Sprees," *Newsweek*, November 5, 2008: http://www.newsweek.com/id/167581

215 "Tracking GhostNet: Investigating a Cyber Espionage Network," Information Warfare Monitor, March 29, 2009: http://www.nartv.org/mirror/ghostnet.pdf

216 Richard B. Schmitt, "Chinese suspected in Capitol hacking cases," *Los Angeles Times*, June 12, 2008: http://articles.latimes.com/2008/jun/12/nation/na-hackers12

217 John Wilson Lewis and Xue Litai, "Strategic Weapons and Chinese Power: The Formative Years," *China Quarterly*, Number 112, December 1987, pp. 541-554. http://www.jstor.org/stable/653778

218 Evan A. Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age*, Stanford University Press, 2003. p. 65.

219 *Report to Congress on Chinese Espionage Activities Against the United States*, CIA/ FBI Report, December 12, 1999: http://www.fas.org/irp/threat/fis/prc_1999.html

and assessing applications for Chinese systems. In a sense, each academy has its own intelligence apparatus that is unique to its own specialty. These institutes also serve as advocates for their projects.[220]

3.3 Illicit Technology Acquisition Targets

The preceding discussion focused on the methodologies China utilizes to acquire information and technology illicitly. The following sub-sections, by contrast, describe various *objects* of these efforts. These include technology related to nuclear weapons, space launch vehicles, and ballistic missiles, as well as economic intelligence unrelated to China's military modernization.

3.3.1 Nuclear Weapons

China is suspected of conducting a systematic espionage campaign against the U.S. nuclear weapons establishment over the course of several decades, beginning in the 1970s. Revelations of this activity came to the public light in March 1999 and coincided with the termination of Wen Ho Lee, who had been the focus of an FBI investigation since 1997. The United States became aware of PRC espionage activities against U.S. nuclear secrets in 1995 following an unsolicited "walk-in" (later determined to have acted at the direction of PRC intelligence), who provided the CIA with a secret Chinese document containing classified U.S. design information related to the W-88 warhead.[221] Following a far-reaching investigation, an unclassified damage assessment concluded that technical advances in China's nuclear weapons were made "on the basis of classified and unclassified information derived from espionage, contact with U.S. and other countries' scientists, conferences and publications, unauthorized media disclosures, [and] declassified U.S. weapons information…"[222]

The Cox Report, issued in 1999, found that China had obtained secret information on each of the seven thermonuclear warheads deployed in the U.S. inventory—the W-88 Trident D-5 warhead, W-56 Minuteman II, W-62 Minuteman III, W-70 Lance, W-76 Trident C-4, W-78 Minuteman III Mark 12A, and the W-87 Peacekeeper.[223] Media reports during this period painted alarming portraits of the depth of Chinese penetration of the U.S. nuclear weapons establishment. For example, Newsweek recounted the reaction of top American weapons experts to a CIA briefing on its "damage assessment" of Chinese spying, in which the experts "practically fainted." The appearance of insider phrases and program descriptions from the nation's weapons laboratories caused one unnamed official to declare that "Chinese penetration is total" and that its espionage activities reach "deep, deep into the labs' black programs."[224]

3.3.2 Space Launch Vehicles and Ballistic Missiles

One apparent beneficiary of ill-gotten foreign technology is China's ballistic missile/space launch vehicle (SLV) program. According to Richard Fisher, the PRC's January 2007 ASAT test used the Kaituozhe-1 (KT-1) SLV, an adaptation of its DF-21 ballistic missile. The KT-1 is believed to have made use of solid fuel rocket technology illegally acquired in 1994 from the Martin Marietta Corporation, which has since

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220 Mark A. Stokes, *China's Strategic Modernization: Implications for the United States*, U.S. Army War College, Strategic Studies Institute, September 1999, p. 23: http://www.fas.org/nuke/guide/china/doctrine/chinamod.pdf

221 *Report of the Select Committee on U.S. National Security and Military / Commercial Concerns with the People's Republic of China.* U.S. House of Representatives, January 3, 1999: http://www.house.gov/coxreport/. p. 63.

222 "The Intelligence Community Damage Assessment on the Implications of China's Acquisition of US Nuclear Weapons Information on the Development of Future Chinese Weapons," Central Intelligence Agency, April 21, 1999: http://www.fas.org/sgp/news/dci042199.html

223 *Report of the Select Committee on U.S. National Security and Military / Commercial Concerns with the People's Republic of China*, U.S. House of Representatives, January 3, 1999: http://www.house.gov/coxreport/. p. 60.

224 John Barry and Gregory L. Vistica, "The Penetration Is Total," *Newsweek*, March 29, 1999.

been acquired by Lockheed.[225] In 2000, Lockheed agreed to pay a $13 million fine for violations of arms export laws.[226] Heavy fines were levied with some regularity during the 2000s against other major American defense contractors for illegal dealings with China. In 2008, the U.S. Department of Justice announced indictments of numerous U.S. companies for violations of American technology export laws. The technologies illegally sold to China included rocket launch data and missile technology, Space Shuttle technology, UAV technology, and night vision technology.[227] Additionally, the espionage charges lodged against Dongfan "Greg" Chung principally concerned space systems. Dongfan, a former Rockwell International and Boeing engineer, was imprisoned for passing to the PRC information concerning the U.S. Space Shuttle and the Delta IV space launch rocket.[228]

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225 "China's successful anti-missile test," *IISS Strategic Comments*, Volume 16, Comment 6, February 2010: http://www.iiss.org/publications/strategic-comments/past-issues/volume-16-2010/february/chinas-successful-anti-missile-test/ See also Richard Fisher, Jr., "China's Direct Ascent ASAT," International Assessment and Strategy Center, January 20, 2007: http://www.strategycenter.net/research/pubID.142/pub_detail.asp

226 David Sanger, "U.S. Fines Lockheed $13 Million in China Satellite Case," *New York Times*, June 14, 2000: http://www.nytimes.com/2000/06/14/world/us-fines-lockheed-13-million-in-china-satellite-case.html?pagewanted=1

227 "More Than 145 Defendants Charged in National Export Enforcement Initiative During Past Fiscal Year," U.S. Department of Justice press release, October 28, 2008: http://www.usdoj.gov/opa/pr/2008/October/08-nsd-958.html

228 Gillian Flaccus, "Dongfan 'Greg' Chung, Chinese Spy, Gets More Than 15 Years In Prison," Associated Press, February 8, 2010: http://www.huffingtonpost.com/2010/02/08/dongfan-greg-chung-chines_n_454107.html

SECTION 4: REVERSE-ENGINEERING

China's acquisition of foreign weapons and technology often serves dual purposes. In addition to performing a stop-gap function—fulfilling a requirement in the short-term that China cannot or has chosen not to meet with indigenous systems—these acquisitions frequently provide prototypes on which future PLA weapons can be based. These prototypes are dissected and studied in a process known as reverse-engineering (*guo chan hua*). The U.S. Defense Department's 2009 assessment of Chinese military power reported that the PRC relies on foreign technology acquisition, often "for the purpose of reverse engineering," in the following key areas: guidance and control systems, turbine technology, precision machine tools, diagnostic equipment, rapid prototyping technology, and computer-assisted design and manufacturing.[229]

Historical Precedent

The contemporary Chinese practice of reverse-engineering is consistent with an approach that China has employed for more than a century, in which its technical personnel have looked to the study of foreign technology as a staple of the nation's modernization effort. Some of China's earliest attempts at reverse-engineering occurred during the "Self-Strengthening Movement" of the 19th century, when the Chinese sought to incorporate Western technology following a series of military disasters at the hands of Europeans. Purchasing rifles and cannon from Britain, Germany, and the United States, Chinese engineers studied the weapons and eventually produced indigenous copies.[230] While this undertaking produced some successes, subsequent losses in the Sino-French War and the Sino-Japanese War essentially brought the movement to a halt.

Efforts to clone Western technology resumed in earnest after the founding of the PRC and have figured prominently in the country's modernization ever since.[231] However, a certain mythology surrounds China's use of reverse-engineering, and many anecdotes have undoubtedly been dramatized for narrative effect. One example concerns the efforts of Chinese scientists to salvage technical documents left behind when Soviet personnel evacuated the country after the 1960 Sino-Soviet split. According to one version of the story, these Soviet advisers shredded a great quantity of materials containing sensitive nuclear weapons information, which the Chinese then painstakingly reconstructed. The information gleaned from the documents supposedly proved crucial to the Chinese, who detonated a nuclear device in 1964. While this story may have been embellished, it has nonetheless become something of a metaphor for Chinese diligence in achieving technological breakthroughs using ill-gotten foreign technology.[232]

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[229] *Annual Report to Congress: Military Power of the People's Republic of China 2009*, Office of the Secretary of Defense: http://www.defense.gov/pubs/pdfs/China_Military_Power_Report_2009.pdf

[230] Larry M. Wortzel, "Risks and Opportunities of a Rising China," Lecture delivered at ASIS International/CSIS conference on "The Asian Century for Business: A Security Challenge," Washington, D.C., May 23, 2006 http://www.heritage.org/Research/Lecture/Risks-and-Opportunities-of-a-Rising-China

[231] In addition to supporting weapons development, China's use of reverse-engineering is believed to figure prominently in many commercial domains in which its technology lags behind the West. Larry Wortzel, a member of the U.S.-China Economic and Security Review Commission and a former Army attaché in Beijing, relates a revealing anecdote from a 1988 visit to a state-run electronics factory. During a tour of the facility, Wortzel encountered a "research lab" consisting of "several technicians carefully dismantling Nokia and Motorola cellular phones and then diagramming and cataloging their parts and design." See Larry Wortzel, "Risks and Opportunities of a Rising China," Lecture delivered at ASIS International/CSIS conference on "The Asian Century for Business: A Security Challenge," Washington, D.C., May 23, 2006.

[232] Jonathan D. Spence, *The Search for Modern China*, W.W. Norton & Company, Ltd., 1990. p. 589.

In another case, sometime in the late 1970s or early 1980s, the PRC reportedly came into possession of at least one U.S. Mark 46 torpedo. By one account, the torpedo was recovered from the nets of Chinese fishermen, who dutifully transferred it to the PLA. Over a period of several years, the torpedo was successfully duplicated, providing the Chinese with the Yu-7 light anti-submarine warfare (ASW) torpedo.[233] Yet another frequently cited (and perhaps apocryphal) example of China's reverse-engineering concerns its alleged receipt of several unexploded U.S. Tomahawk cruise missiles that had been fired against al-Qaeda targets in Afghanistan in 1998.[234] The purchase of these missiles was assumed to stem from China's interest in studying their guidance and avionics technology,[235] though there has been no confirmation of the transaction, and U.S. intelligence officials profess skepticism that it ever occurred.[236] In yet another case, Chinese engineers supposedly harvested technology for China's J-10 fighter aircraft from a U.S. F-16 fighter covertly delivered by its ally Pakistan.[237]

While separating truth from lore is often a difficult analytical task in assessing China's feats of reverse-engineering, a number of cases conclusively establish that the Chinese have benefited enormously from reconstructing foreign technology. During the 1969 Sino-Soviet conflict, for example, Chinese forces on the disputed Zhenbao Island captured a Soviet T-62 main battle tank, which was disassembled and examined by Chinese technical personnel. The T-62's night vision technology was ultimately incorporated into the Type 69 tank, China's first independently manufactured tank and itself an enhanced version of China's copy of the Soviet T-54A.[238] More recent copies of foreign ground vehicles include the Shenyang Aircraft Industry Corporation SQF2040 *Zhanshen* and the Dongfeng Motors EQ2050 *Mengshi*—Chinese versions of the U.S. General Motors M998 HMWWV ("Humvee") vehicle.[239] Yet, reverse-engineering has been observed in far more technologically sophisticated systems, which are generally acquired under more formal circumstances than stumbling upon them on the battlefield.

Reverse-Engineering High-Tech Weapons

China's development of the J-11B fighter aircraft, the PLAAF version of Russia's Su-27SK Flanker, is illustrative of its approach to studying and replicating imported technology. After purchasing a license in 1995 to produce 200 of the aircraft from assembly kits, Chinese engineers achieved breakthroughs in engine technology and other aircraft components. These advances allowed them to discontinue importation of the kits after producing only 95 aircraft and thereafter rely on indigenously produced avionics.[240] In another more brazen case, the Chinese reportedly acquired a prototype T-10K shipborne fighter, a version of the Russian Su-33 fighter, from the Ukrainian Research Test and Flying Training

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233 Stephen V. Mladineo and Charles D. Ferguson, "On the Westinghouse AP 1000 Sale to China and its Possible Military Implications," Nonproliferation Policy Education Center (NPEC) Research Memorandum, 2007: http://www.npec-web.org/Essays/20070311-MladineoFerguson-WestinghouseSaleToPrc.pdf

234 John Barry and Gregory L. Vistica, "The Penetration Is Total," *Newsweek*, March 29, 1999.

235 See also Geoffrey T. Lum, "China's Cruise Missile Program," *Military Review*, January/February 2004; and Richard Fisher, Jr., "China's New Strategic Cruise Missiles: From the Land, Sea and Air," International Assessment and Strategy Center, June 3, 2005: http://www.strategycenter.net/research/pubID.71/pub_detail.asp

236 Peter Finn, "Secret Tape Suggests China-Bin Laden Link; CIA Casts Doubt on Missile Technology Deal," *Washington Post*, October 20, 2001.

237 David Isenberg, "Israel's role in China's new warplane," *Asia Times*, December 4, 2002: http://www.atimes.com/atimes/China/DL04Ad01.html

238 "Type 69/79 Main Battle Tank," SinoDefence.com, February 20, 2009: http://www.sinodefence.com/army/tank/type69.asp

239 "EQ2050 Light Utility Vehicle," SinoDefence.com, February 13, 2009: http://www.sinodefence.com/army/logistics/eq2050.asp

240 "China copies Su-27 fighter, may compete with Russia – paper," *RIA Novosti*, February 21, 2008: http://en.rian.ru/russia/20080221/99765686.html

Center (NITKA) for the purpose of cloning the aircraft.[241] According to one media report, "[b]y dissecting the T-10K—an earlier variant of the Sukhoi Su-33 fighter—China hopes to acquire the capability to independently develop its own shipborne fighters" to support its aircraft carrier program.[242] The Chinese version of the aircraft has been named the J-15 and is being manufactured by the Shenyang Aircraft Company.[243]

The Chinese have shown a particular affinity for copying foreign missiles to perform a variety of military roles. In 1982, the PRC purchased from Israel the Python-3 air-to-air missile, a weapon similar in design to the American AIM-9L Sidewinder, along with the right to co-produce the missile under license. The Chinese-made Python, dubbed the PL-8, began to be produced from a set of 1,200 Israeli kits in 1988. Meanwhile, China systematically replaced the missile's Israeli components and by the late 1990s had achieved an indigenous weapon.[244] The Chinese apparently also developed the HQ-7 air defense missile by reverse-engineering France's Crotale missile system; the same method was used to copy the Italian Aspide air-to-air missile.[245] Additionally, as part of the deal China negotiated for Russian *Sovremenny* class destroyers, the PLA acquired a number of 3M-80E Moskit (NATO designation SN-X22 Sunburn) nuclear-capable cruise missiles, which it subsequently used to produce a Chinese variant.[246] Open-source reports also suggest that China is attempting to replicate the technology used in the S-300 air defense system acquired from Russia.[247]

"Human Wave" Technology Gathering

While the term "reverse-engineering" tends to suggest the study of a weapon or technology sample that has made its way into technicians' hands, a Chinese variant of this practice involves assigning scientific personnel, often in excessive numbers, to soak up foreign technology wherever they can find it. Because the activity does not necessarily involve the study of a physical object, it cannot accurately be called reverse engineering. And because it often takes place openly—if clumsily—the term "espionage" is ill-fitting as well. Whatever its label, the practice is commonly associated with China's technology acquisition effort and appears to have been used consistently for decades.

One account of this approach was seemingly scripted to fulfill the Western analytic narrative of China's approach to military modernization, which centers on its rapacious pursuit of foreign technology and the application of China's unique manpower strength to every conceivable problem. During the 1980s, an arrangement was struck between the PRC and the United States to upgrade the avionics of the PLAAF's F-8-II fighter aircraft. Under the "Peace Pearl" program, the American Grumman Corporation was contracted to incorporate an advanced radar and other electronics into two Chinese aircraft. Once the procedure was taught to Chinese personnel, 55 additional fighters were to be upgraded by the Shenyang Aircraft Company. According to one account, the Chinese took the greatest advantage of this

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241 Wendell Minnick, "Is China Stealing Russia's Su-33?" *Defense News*, May 4, 2009: http://www.defensenews.com/story.php?i=4070484

242 Andrei Chang, "Analysis: Ukraine aids China carrier plan," *United Press International*, December 10, 2008: http://www.spacewar.com/reports/Analysis_Ukraine_aids_China_carrier_plan_999.html

243 "China Making First J15 Ship-Borne Fighter," *Kanwa Asian Defense*, May 1, 2010. Open Source Center: CPP20100511702017.

244 "PiLi-8 Short-Range Air-to-Air Missile," SinoDefence.com, October 12, 2008: http://www.sinodefence.com/airforce/weapon/pl8.asp; Israel's assistance in this process calls into question whether this effort should be described as a pure case of reverse engineering. See Yitzhak Shichor, "Israel's Military Transfers to China and Taiwan," *Survival*, Volume 40, Number 1, Spring 1998.

245 "U.S. and European Union Arms Sales since the 1989 Embargoes," General Accounting Office, GAO/T-NSIAD-98-171, April 28,1998: http://www.gao.gov/archive/1998/ns98171t.pdf

246 "Reframing China Policy Debate 3: Is China's Military Modernization Program a Growing Threat to the United States and Asia?" Carnegie Endowment for International Peace, New Vision Program, February 6, 2007: www.carnegieendowment.org/files/debate_3%20final%20transcript.pdf

247 Wendell Minnick, "China Shifts Spending Focus to Info War," *Defense News*, September 2006.

opportunity—technicians who were assigned to observe the initial upgrades at a Grumman facility were rotated every few weeks to maximize the number of personnel receiving the coveted instruction.[248]

Contemporary reporting appears to echo the perception of China's reliance on "human wave" technology gathering expeditions. One recent description of Chinese activity at the Russian Aeroengines aircraft technology trade show in Moscow described a group of 30 Chinese specialists who fanned out to collect information on Russian jet-propulsion systems. A Russian aerospace industry analyst described the Chinese presence as "just over the top" and consisting of "too many people—like ants on the march." Another Russian analyst suggested that there were "so many Chinese huddled around the mock-up of the Saturn TRDD-50 [cruise missile] engine at this show it reminded me of bees buzzing around honey."[249] In another case, Defense Intelligence Agency analyst Nicholas Eftimiades describes a particularly ham-fisted attempt by Chinese scientists to obtain foreign technology for reverse-engineering purposes. According to Eftimiades, several Chinese delegates at a Paris trade show were witnessed dipping their neckties into a film processing solution manufactured by the German company Agfa, presumably to gather a sample of the solution for later analysis.[250]

In another technology-gathering expedition, a delegation from the PRC's "409 Issue Technical Expert Group"—a scientific body believed to be responsible for developing the country's antisatellite weapon and ballistic missile defense programs—recently visited American research institutes in search of relevant technical information. An anonymous former U.S. defense official suggested that the delegation's purpose was "to consult with U.S. experts in order to overcome technical problems associated with the [kinetic kill vehicle]." (For a more detailed description of kinetic kill vehicles, see Case Study: Hit-to-Kill Technology in Section 7). According to the official, Chinese personnel "don't necessarily 'steal' technology. They go in the front door and ask for advice from U.S. and presumably other countries' civilian academic institutions. Not too much that's sneaky about it."[251]

The Future of Reverse-Engineering

Despite China's long history of acquiring and reverse-engineering technology prototypes, some experts are skeptical that this practice remains feasible for the most advanced weapons given their increasing dependence on software. Indeed, Yitzhak Shichor argued—more than a decade ago, when weapons were considerably less sophisticated than they are today—that "[i]n the high-technology era, reverse-engineering or copy-production of an advanced weapon system is practically impossible. Hardware can be disassembled and then redesigned and reproduced, but software—increasingly the key element—cannot."[252] Yet even if reverse-engineering retains some utility in the high-tech era, a number of other considerations suggest that the method will diminish over time as a source of China's advanced technology.

Most of these considerations involve weighing the short-term benefit of acquiring military capabilities through reverse-engineering against the long-term costs associated with the practice. For example, cloning weapons purchased from Russia might allow Chinese engineers to shave off years of trial and error, but China's disdain for intellectual property rights could compromise future arms sales. High-tech

[248] "Polishing the Pearl," *The Economist*, June 11, 1988.
[249] Reuben F. Johnson, "China eager for Russian air technology," *Washington Times*, May 4, 2010: http://www.washingtontimes.com/news/2010/may/04/china-eager-for-russian-air-technology/print/
[250] Nicholas Eftimiades, testimony before the Joint Economic Committee, U.S. Congress, May 20, 1998: http://www.house.gov/jec/hearings/intell/eftimiad.htm
[251] Wendell Minnick, "China Missile Test Has Ominous Implications," *Defense News*, January 19, 2010: http://www.defensenews.com/story.php?i=4460204
[252] Yitzhak Shichor, "Israel's Military Transfers to China and Taiwan," *Survival*, Volume 40, Number 1, Spring 1998.

weapon manufacturers will be hesitant to relinquish hard-earned advances to unscrupulous foreign buyers, especially when the copied technology may be cheaply marketed to third countries and compete with the original design.[253] Indeed, Russian negotiators reportedly halted talks over China's acquisition of Su-33 fighters after discovering China's effort to copy the Su-27SK.[254]

Another objection to reverse-engineering is that the products of such efforts offer only temporary parity with technologically sophisticated adversaries, whose continuing development of new capabilities presents a constantly moving target. As Richard A. Bitzinger observes, "by the time the Chinese have perfected a reverse-engineered system, the 'state-of-the-art' has progressed to the next level, leaving the PLA with a weapon that, although an improvement to its current arsenal, does little to narrow the technological gap with its competitors."[255] There appears to be some recognition of this concern among senior Chinese strategists. One such individual is Zhang Zhaozhong, director of the Military Science and Technology Education and Research Office at China's National Defense University. According to a 2005 RAND Corporation analysis of China's defense industry, Zhang "strongly opposes reverse engineering and copy-production ('studied imitation') as a means for advancing China's military technology, because such an approach would leave China in a position of perpetually lagging behind the most advanced military powers."[256]

Yet, there is an even more fundamental disincentive to rely on reverse-engineering for China's acquisition of technology. In addition to being hopeless to the task of keeping pace with foreign weapons development, reliance on reverse-engineering comes at the expense of building up China's long-term capacity for indigenous innovation. Bitzinger notes that the process of reverse-engineering is "often a time- and resource-consuming chore—sometimes to the point of starving other, more cutting-edge R&D."[257] In this regard, the short-term realization of a military capability may come at the expense of broader developments over a longer period.

Finally, beyond these practical considerations—comprising bilateral relations, chasing constantly moving technology targets, and undercutting indigenous R&D—perhaps the most compelling argument against reverse-engineering concerns the more abstract concept of national prestige. If the statements of China's leaders over the past half-century are to be believed, the Chinese have pursued scientific achievements in part for a reason extending far beyond the tangible capabilities these technologies provide. In the words of Deng Xiaoping, such achievements "demonstrate a nation's abilities and are a sign of its level of prosperity and development."[258] For a nation with such pronounced self-regard for its historical scientific achievements, mere *possession* of advanced technology is an insufficient source of national pride. Reliance on the process of reverse-engineering would amount to a tacit admission that China is incapable of acquiring the most advanced technologies without some form of foreign assistance. In the long term, such a policy is incompatible with China's national scientific aspirations.

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253 Dmitry Sudakov, "Russia infuriated with Chinese export copies of Su-27 jet fighters," *Pravda*, May 22, 2008: http://english.pravda.ru/russia/economics/22-04-2008/104975-russia_china-0

254 Wendell Minnick, "Is China Stealing Russia's Su-33?" *Defense News*, May 4, 2009: http://www.defensenews.com/story.php?i=4070484

255 Richard A. Bitzinger, "Going Places or Running in Place? China's Efforts to Leverage Advanced Technologies for Military Use," in Susan M. Puska, ed., *People's Liberation Army After Next*, Strategic Studies Institute, U.S. Army War College, August 2000: http://www.strategicstudiesinstitute.army.mil/pdffiles/PUB67.pdf

256 See Zhang Zhaozhong, "Master New Development Trends of Military Equipment," *Jiefangjun bao,* April 14, 1998. As cited in Evan S. Medeiros, et al., "A New Direction for China's Defense Industry," RAND Corporation monograph, 2005: http://www.rand.org/pubs/monographs/2005/RAND_MG334.pdf

257 Bitzinger, op. cit.

258 "China Must Take Its Place in the Field of High Technology," *People's Daily*, October 24, 1988: http://english.cri.cn/1325/2004-8-5/20@138368.htm

SECTION 5: INDIGENOUS RESEARCH AND DEVELOPMENT

So essential are indigenous scientific advances to Chinese leaders' ambitions for their country that the current emphasis on R&D in China, at least rhetorically, is difficult to overstate. Characteristic of official PRC pronouncements on the subject is Premier Wen Jiabao's declaration in 2005 that "Independent innovations are crucial to the rapid rise of a country." While Wen noted that China must "learn from the world's achievements in advanced science and technology," he argued that independent advances are necessary because "it is impossible to buy core technology."[259] This rhetorical emphasis, which is increasingly being matched by tangible investments in China's R&D infrastructure, represents a stark turnabout from the nation's policies of just a few decades earlier, when the Cultural Revolution roiled China's technological development.

R&D During the Cultural Revolution

During the late period of Mao's rule, the PRC's turbulent political milieu took a heavy toll on Chinese scientists, who, like other intellectuals, were systematically persecuted and science itself was denounced as "elitist" and "bourgeois."[260] As a report of the U.S.-China Economic and Security Review Commission recounts, the Cultural Revolution devastated China's technological development as "universities were closed, and professors and students were killed, jailed, or sent to the countryside to work on farms. An entire generation of Chinese researchers and expertise was lost."[261] This phenomenon reached virtually every sphere of study in China, and defense R&D was no exception. Richard A. Bitzinger describes Mao Zedong's "fitful efforts at creating a truly proletarian society in China" as having "disastrous consequences for military R&D, especially for the development and introduction of more technological weapon systems."[262]

Even amidst the chaos of Mao's rule, China did boast a number of impressive technological achievements. Chief among these were its largely independent development of nuclear and thermonuclear weapons in the early 1960s, as well as the creation of an impressive ballistic missile program. Indeed, Bitzinger observes that "it has become almost *de rigueur* to refer to China's missile industry as an 'island [or pocket] of excellence' in the country's military-industrial complex."[263] Yet more than two decades later, such accomplishments did not extend far beyond the realm of strategic weaponry. According to Evan Feigenbaum, by the late 1970s the "endemic stagnation in R&D during the Mao years meant that only the strategic weapons system had created organizational and management institutions conducive to rapid and sustained technical progress at (roughly) international standards." While the leaders of China's strategic weapons programs fostered cross-system collaboration, design competition, and scientific peer review, Feigenbaum recounts, most non-defense technology

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[259] As cited in Michael Pillsbury, "China's Progress in Technological Competitiveness: The Need for a New Assessment," Prepared for the U.S.-China Economic and Security Review Commission, April 21, 2005: http://www.uscc.gov./researchpapers/2005/05_04_21_technological_progress.pdf

[260] Evan A. Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age*, Stanford University Press, 2003. p. 78.

[261] *2007 Report to Congress of the U.S.-China Economic and Security Review Commission.* November 2007: http://www.uscc.gov/annual_report/2007/report_to_congress.pdf

[262] Richard A. Bitzinger, "Arms to Go: Chinese Arms Sales to the Third World," *International Security*, Volume 17, Number 2, Autumn 1992: http://www.jstor.org/stable/2539169

[263] Richard A. Bitzinger, "Going Places or Running in Place? China's Efforts to Leverage Advanced Technologies for Military Use," in Susan M. Puska, ed., *People's Liberation Army After Next*, Strategic Studies Institute, U.S. Army War College, August 2000: http://www.strategicstudiesinstitute.army.mil/pdffiles/PUB67.pdf

development was "fragmented, vertical, and compartmentalized."[264] Only when Deng Xiaoping began to assume political control in the late 1970s was an effort made to reform this suffocating scientific culture and create an environment that encouraged high-technology development on a broad scale.

The drive toward more fulsome national achievements in science and technology would be accelerated by a seminal event in China's modern history—the March 1986 launch of the 863 Program, named after the date of its origin. This event was occasioned by the efforts of four eminent Chinese scientists who appealed to Deng personally to put his authority behind a program for developing advanced technology in China. The scientists' proposal, entitled "Recommendations Concerning Research to Keep Pace with Foreign Strategic High Technology Development," expressed concern that China's theretofore modest technological ambitions were insufficient to ensure the country's economic competitiveness in a world undergoing a "new technological revolution" (*xin jishu geming*).[265] In the months that followed Deng's endorsement of the scientists' vision, China's civil and military bureaucracy responded with a comprehensive outline for national investments in high technology, and the Politburo approved a massive commitment of funds for its implementation.[266]

The ambitious 863 Program would encompass seven fields to improve China's technological standing and produce indigenous innovations. These fields include: the life sciences, information technology, energy, defense, automation, materials science, and aerospace.[267] Though the program was ostensibly a broad-based technology development initiative, encompassing fields with both civilian and dual-use applications, it was co-managed by the now-defunct Commission on Science, Technology, and Industry for National Defense (COSTIND), then China's defense R&D ministry.[268] In 2002, China's State Council approved a second phase that extends out to 2017. While Chinese officials initially released annual reports on the size and nature of 863 Program investments, they ceased doing so in 2002, and the program has become somewhat murky.[269] However, the 863 Program Office continues to provide funding for technology research.

The 863 Program today is broken into six general fields (*ling yu*), which are further divided into 46 subject areas *(keti* or *zhuti*), some of which are designated as priorities. These subject areas are further categorized into specific topics (*zhuanti*). The general civilian fields include information technology, biotechnology, advanced materials, advanced manufacturing, engineering, and environmental technology. In 2004, advanced materials absorbed more than 24 percent of all 863 Program funding. Universities, government affiliated research institutes, and enterprises are qualified to compete for 863 Program grants. Examples of priority focus areas include synthetic aperture radar (SAR), solid state lasers, organic light emitting displays, diamond coatings, advanced tunnel boring machines, and microelectrical

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[264] Evan A. Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age*, Stanford University Press, 2003. p. 129.
[265] Evan Osnos, "Green Giant," *New Yorker*, December 21, 2009: http://www.newyorker.com/reporting/2009/12/21/091221fa_fact_osnos
[266] Gregory Kulacki and Jeffrey G. Lewis, "A Place for One's Mat: China's Space Program, 1956–2003," American Academy of Arts and Sciences, The Reconsidering the Rules of Space Project. 2009: http://www.amacad.org/publications/spaceChina.pdf
[267] Kulacki and Lewis, op. cit. A slightly different collection of technologies appears in Feigenbaum, 2003, p. 157. The seven fields Feigenbaum lists are: biotechnology, energy, information technology, lasers, new materials, and space technology.
[268] Bitzinger, 2000, op. cit.
[269] Ariana Eunjung Cha, "Even Spies Embrace China's Free Market," *Washington Post*, February 15, 2008: http://www.washingtonpost.com/wp-dyn/content/article/2008/02/14/AR2008021403550.html

mechanical systems (MEMS).[270] Unconfirmed sources indicate two additional fields—aerospace and "advanced defense systems"—that are specifically military-related.[271]

In addition to encouraging the application of commercial technologies to military R&D, many research areas cut across multiple fields. For example, engineers can generate greater radar power by using more advanced materials found in microelectronics. In October 2008, the aerospace industry, in partnership with Xidian University, opened a new national-level R&D center in Xian dedicated to the development of advanced semiconductor devices, with a special emphasis on gallium nitride (*danhuajia*) materials.[272]

China's MEMS development serves as an example of its civil-military integration policies, reflected in initiatives such as the 863 Program. MEMS technologies provide a means to reduce the weight volume of guidance systems. They also allow the packaging of millions of instructions per second into very small spaces with very little power consumption. For example, a key focus of China's ASAT 863-801 project was research on a high performance three axis accelerometer chip that enables incredibly small inertial measurement units (IMUs). IMUs have applications in a range of civilian products such as automobile air bags. Indeed, commercial requirements are believed to be driving the need for smaller IMU packages.[273]

While the 863 Program has had its share of successes, the PLA appears to have viewed the 863 Program as insufficient to bridge the gap between basic and applied R&D and targeted military applications. Though further research is needed, one of the deficiencies of the program, at least from the PLA's perspective, may have been the leading role of the civilian S&T authorities under the civilian State Council. While the PLA's defense R&D community was granted authority over funds associated with three of the 863 Program's focus areas, China's civilian S&T authorities presumably have maintained overall management of the 863 Program and resource allocation authority for each focus area based on broader national needs rather than specific PLA requirements.[274]

Yet there can be no doubt that this transformative effort continues to shape China's technological development today both in the direct products of its associated research and in the broader effects of the program on China's scientific culture. (For further discussion of the 863 Program, see Case Study: Hit-to-Kill Technology as well as Case Study: Adaptive Optics for High Energy Laser Applications.) Later centrally-directed R&D efforts would build upon the foundation laid by the 863 Program.

270 Kevin Lei, *Introduction of National High Tech R&D Program: Priorities and Prospects*, briefing, High Tech Research and Development Center, November 9, 2005.

271 The numbering system for 863 Program fields follow a sequence, with 863-1XX covering information technology areas , 863-7XX designating aerospace areas, and 863-8XX designating "advanced defense systems." The latter is likely a euphemism for missile defense and anti-satellite systems. The 863-7 series appears to cover satellite programs, hypersonic vehicle technologies, and space launch systems. For further background on the 863 Program, see "Chen Zhili Discusses Implementation of the 863 Program at the 20th Anniversary Conference" [陈至立在863计划实施20周年纪念大会上的讲话], Nanjing S&T Information Network, January 5, 2007.

272 "Xian Aerospace Base and Xidian University Open New Semiconductor R&D Center," *Xidian University News*, November 5, 2008, at http://paper.xde6.net/html/xdpaper/20081105/xdpaper1867.html. Use of gallium nitrite in military systems is a relatively recent trend. DARPA has a program to develop electronics based on gallium nitrite materials for integration into U.S. systems.

273 See Neil M. Barbour, "Inertial Navigation Sensors," The Charles Stark Draper Laboratory, Inc., NATO Paper (RTO-EN-SET-064).

274 For an excellent overview of the politics behind the 863 Program, see Evan Feigenbaum, "Who's Behind China's High-Technology 'Revolution'?" *International Security*, Summer 1999: http://www.mitpressjournals.org/doi/abs/10.1162/016228899560068

Chinese R&D in the 1990s

By the 1990s, scientific advancement was widely understood to be central to China's long-term economic and military development, and state investment in R&D reflected this recognition. Some observers have referred to China as "techno-nationalist." The premise of techno-nationalism is that competition among modern states hinges on technology. That is, technology not only confers intrinsic prestige in international competition but is also a critical enabler of national defense. Thus, technology is a leading metric of a state's comprehensive national power. Techno-nationalism involves a commitment to use political means to secure technological progress in the interests of national defense and economic advantage for Chinese industry.[275]

In the military realm, key events such as the 1991 Persian Gulf War, 1996 Taiwan Strait Crisis, and 1999 Kosovo campaign prompted substantial funding increases to support the PLA's modernization. This was particularly true after the Kosovo campaign and other events in 1999, when defense R&D centers received across-the-board funding boosts.[276] Yet, the emphasis on investment in science and technology has not been confined to the military realm—similar infusions of funding were also witnessed in the civil sector. These were accompanied by China's characteristic use of information campaigns to signal bureaucratic priorities and mobilize public support. A successor of the 863 Program, dubbed the "Super-863 Program," was unveiled in 1996. Its purpose was to foster technology development in the following areas: machine tools, electronics, petrochemicals, electronic information, bioengineering, novel materials, advanced nuclear research, aerospace engineering, space, and marine technology.[277]

In the years following the 1995 launch of yet another science-oriented campaign, the "Revitalizing the Country through Science, Technology and Education" program (*kejiao xingguo*), the rate of China's general investment in R&D has greatly outstripped the country's general economic expansion.[278] By 2006, China's gross domestic expenditure on R&D (GERD) was estimated at $86.8 billion, placing the PRC behind only the United States and Japan.[279] (According to at least one calculation, the figure is $136 billion in purchasing power parity [PPP] terms, positioning China ahead of Japan's $130 billion in R&D spending.)[280] The PRC's GERD today amounts to some 1.5 percent of China's gross domestic product (GDP), compared to the 2.7 percent the United States devotes to R&D.[281] China's R&D operations tend to be concentrated in eastern China, centered on a dozen or so universities that produce the scientific talent that R&D centers need. "First tier" R&D cities include Beijing; Shanghai and the Yangzi River Delta region; and Guangzhou/Shenzhen. "Second-tier" R&D cities include Nanjing,

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275 See Barry Naughton and Adam Segal, "Technology Development in the New Millennium: China in Search of a Workable Model," conference paper, *Innovation and Crisis: Asian Technology after the Millennium*, Cambridge, September 15-16, 2000, MIT Japan Program, Working Paper 01.03. For a general discussion of techno-nationalism, see Richard Samuels, *Rich Nation, Strong Army: National Security and Technological Transformation in Japan*, (Ithaca: Cornell University Press, 1994). See also E.C. McKay, "Computer Chips and National Glory: China's Techno-nationalism as a Legitimation Strategy," Paper presented at the International Studies Association 48th Annual Convention, Chicago, Illinois, December 11, 2008: http://www.allacademic.com/meta/p180936_index.html

276 Gregory Kulacki and Jeffrey G. Lewis, "Understanding China's Antisatellite Test," *Nonproliferation Review*, Volume 15, Number 2, July 2008: http://cns.miis.edu/npr/152toc.htm

277 See Chapter 1: PRC Acquisition of U.S. Technology, *Report of the Select Committee on U.S. National Security and Military / Commercial Concerns with the People's Republic of China.* U.S. House of Representatives, January 3, 1999: http://www.house.gov/coxreport/

278 Cong Cao, Denis Fred Simon, and Richard P. Suttmeier, "China's Innovation Challenge," *Innovation: Management, Policy & Practice*, Volume 11, Issue 2, August 2009: http://china-us.uoregon.edu/pdf/chinasInnovationchallenges.pdf

279 "OECD Science, Technology and Industry Outlook 2008: Highlights." Organization for Economic Cooperation and Development, 2008: http://www.oecd.org/dataoecd/18/32/41551978.pdf

280 Denis Fred Simon, Cong Cao and Richard P. Suttmeier, "China's New Science & Technology Strategy: Implications for Foreign Firms," *China Currents*, Spring 2007: http://www.chinacurrents.com/spring_2007/cc_simon.htm

281 National Science Board, *Science and Engineering Indicators 2010*, Chapter 4: Research and Development: National Trends and International Linkages, National Science Foundation (NSB 10-01), Arlington, VA: 2010: http://www.nsf.gov/statistics/seind10/c4/c4h.htm

Suzhou, Xi'an, and Wuhan. In 2006, Beijing, Guangdong, and the Yangzi River Delta region accounted for 52 percent of all R&D spending in China and almost 56 percent of all S&T funding.[282]

Despite this progress, however, in most domains China's development of indigenous technology remains far from world-class. Chinese civil institutions and commercial facilities continue to rely on Western innovations. According to some observers, this reliance comes at the expense of the very technological independence China has long sought to achieve. To wit, Richard Suttmeier has drawn attention to a series of articles in the PRC's state-run newspaper, the *People's Daily*, in 2005, which offered candid insights into the poor state of indigenous scientific innovation in China. Entitled "Giving Full Play to Scientific, Technical Progress," the series observed that "China's industries' technological level and their abilities in self dependent innovation are still low." In addition to lacking "core" technology, Chinese companies "depend on foreign companies for crucial parts, are at the lower end or the middle range of the global industrial chain, [and] rely on multinational companies for technological support…" Suttmeier notes the contrast between widespread perceptions of China's absorption of Western technology and the reality of continued dependence on foreign knowledge, which he argues continues to impede China's technological development:

> China has imported vast amounts of foreign technology over the past 20 years and this has contributed in no small way to the quality and rapidly increasing technological sophistication of Chinese exports. This technology transfer experience, though, has affected the [national system of innovation] negatively in two ways. Unlike Japan, and later Korea, China has devoted considerably less energy towards assimilating foreign technology, with the result that the technological dependency…has, if anything, worsened. In addition, foreign technology has enjoyed a privileged position in Chinese industry relative to domestically developed technology due both to the often superior performance characteristics of the foreign technology, the failures of the domestic technology diffusion system, and psychological and cultural orientations reflecting the belief in the superiority of foreign technology.[283]

Suttmeier observes that while the Chinese have "approached the use of foreign technology pragmatically, to improve business performance," the *People's Daily* critique "laments the fact that there has not been a strong tradition of using technology imports for technological learning."[284] Perhaps in response to this recognition, various programs have been enacted that signal China's ambition to produce more domestic innovations over time and rely less on foreign technology. For example, the 2006 Medium and Long-term National Plan for Science and Technology Development 2006–2020 (referred to hereafter as the Mid-to-Long Term S&T Plan) contained the national objective of becoming an "innovation-driven country" by 2020.[285] The plan articulates a tri-pronged strategy for achieving this goal, including the incorporation of foreign technologies, or "re-innovation" (*yinjin xiaohua xishou zaichuangxin*); novel adaptations of extant technology, or "integrated innovation" (*jicheng chuangxin*); and the pursuit of "original innovation" (*yuanshi chuangxin*).[286]

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[282] Evan Thorpe, "Bringing R&D to China," *China Business Review*, Nov/Dec 2008.
[283] Richard P. Suttmeier, testimony before the U.S.-China Economic and Security Review Commission hearing on "China's High Technology Development," April 21-22, 2005: http://www.uscc.gov/hearings/2005hearings/transcripts/05_04_21_22.pdf
[284] Richard P. Suttmeier, op. cit.
[285] Mu Rongping and Qu Wan, "The development of science and technology in China: A comparison with India and the United States," *Technology in Society*, 30 (2008), 319-329. Also translated as "innovation-oriented society"; see Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China's 15-year Science and Technology Plan," *Physics Today*, December 2006: http://www.levininstitute.org/pdf/Physics%20Today-2006.pdf
[286] Denis Fred Simon, Cong Cao and Richard P. Suttmeier, "China's New Science & Technology Strategy: Implications for Foreign Firms," *China Currents*, Spring 2007: http://www.chinacurrents.com/spring_2007/cc_simon.htm

China's Mid-to-Long Term S&T Plan cuts a wide swath. It includes 68 priorities spread across 11 key areas that are important to China's economic development; 16 special research projects, such as "core electronic devices;" "extremely large-scale integrated circuit manufacturing technologies;" "wideband wireless mobile communications technology"; "new transgenic biological varieties", "large-scale advanced pressured-water reactor"; "prevention of infectious diseases such as AIDS and hepatitis"; large aircraft R&D, and manned space flight. It also includes eight "cutting-edge" technology areas, including biotech, IT, new materials, advanced manufacturing, advanced energy, marine technologies, lasers, and aerospace. Its eight "cutting edge" science challenges include cognitive science, deep structure of matter, pure mathematics, and Earth systems science. Its four major new research programs include protein research, nanoscience, growth and reproduction, and quantum modulation research.[287]

In many ways, the strategy laid out in the Mid-to-Long Term S&T Plan mirrors a crucial dimension of the PRC's approach to military modernization in which foreign technologies are used to fulfill short- and medium-term PLA needs until the country's military-industrial complex is able to achieve advanced capabilities indigenously. Tai Ming Cheung has described this endeavor as the "transition from creative imitation to indigenous innovation."[288] The emphasis on innovation is conspicuous in China's 2008 defense white paper, which notes that "China is accelerating reform and innovation in its defense-related science, technology and industry…enhancing the capabilities of independent innovation in the R&D of weaponry and equipment, and striving to establish a new system of defense-related science, technology and industry…"[289]

Selective Modernization of the PLA

In light of China's painful experience in 1960, when the Soviet Union abruptly discontinued weapons and technology transfers, the Chinese are extremely wary of excessive reliance on foreign arms.[290] Not only does such dependence place China at the mercy of its suppliers, but acquiring its most coveted weapons from abroad might also allow powerful rivals, especially the United States, to exercise pressure on China's trading partners to restrict sales to the PRC. For example, Erik Lin-Greenberg highlights the susceptibility of China's air force modernization effort to external pressures as a consequence of its reliance on Russian, Israeli, French, and German technology. He suggests that "[o]utsourcing the development of the Chinese air force to foreign nations allows the United States to influence many of China's weapons suppliers through incentives or punitive measures."[291] Eager to minimize this vulnerability, Chinese leaders have emphasized the development of indigenous aircraft to ensure the PLAAF is not beholden to foreign powers.

The drive to modernize China's armed forces has not been uniform across military capabilities. Rather, the available literature widely suggests that Chinese leaders have adopted a policy of "selective modernization" in which they have made significant R&D investments in certain advanced technologies while remaining content to acquire others from abroad.[292] Investments in indigenous technology are generally reserved for the capabilities deemed most critical to China's security. In the early decades of

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[287] Among various sources, see Alan Wolff, "China's Drive Toward Innovation," *Issues in Science and Technology*, Spring 2007, pp. 54-63.
[288] Tai Ming Cheung, "The Rise of China China's Dual Dual-Use Technological Base and the Implications for Asia," Institute on Global Conflict and Cooperation, University of California, San Diego, May 13, 2005: http://www.aei.org/docLib/20050512_TaiMingCheung.pdf
[289] *China's National Defense in 2008*, January 2009.
[290] Yitzhak Shichor, "Israel's Military Transfers to China and Taiwan," *Survival*, Volume 40, Number 1, Spring 1998.
[291] Erik Lin-Greenberg, "Offensive Airpower with Chinese Characteristics," *Air & Space Power Journal* , Fall 2007: http://www.airpower.maxwell.af.mil/airchronicles/apj/apj07/fal07/greenberg.html
[292] Evan S. Medeiros, Roger Cliff, Keith Crane, James C. Mulvenon, "A New Direction for China's Defense Industry," RAND Corporation monograph, 2005: http://www.rand.org/pubs/monographs/2005/RAND_MG334.pdf. p. 24.

the PRC's existence, these capabilities included China's nuclear deterrent and ballistic missile delivery systems. Later the list grew to include precision-strike and anti-access weapons,[293] which in the present day include China's increasingly sophisticated ASAT capability and its reported development of an anti-ship ballistic missile.[294] This decision, which dates to the late 1950s and early 1960s, was driven in part by an understanding that attempting to master too broad a suite of technologies could hamstring the nation's science and technology infrastructure.

Evan Feigenbaum recounts a contest between competing factions in China during this period, when a protracted internal debate took place over future technology development. Some Chinese officials, he notes, believed that "ambitions for the construction of a basic technological infrastructure would unquestionably be jeopardized by the expense of R&D involved in complex strategic weapons technologies."[295] An object lesson in the overzealous pursuit of technology is perhaps Mao's 1963 decision, known as the "640 Directive," that in addition to deploying nuclear weapons, China should also field a ballistic missile defense capability. R&D under "Project 640"—the outgrowth of Mao's directive—included nuclear-armed anti-ballistic missiles, an anti-missile "super gun," and an advanced early warning network. Progress on these systems continued until Deng Xiaoping's decision in 1980 that the program was costly and superfluous and should therefore be discontinued.[296]

Defense-Oriented R&D in the 2000s and Beyond

In spite of institutional overhauls dating back to the 1980s, as recently as a decade ago Bernard D. Cole and Paul H.B. Godwin described the Chinese military-industrial complex as a "huge, lumbering, obsolescent behemoth built with Soviet assistance in the 1950s."[297] Despite substantial progress in China's indigenous defense-industrial capacity, a number of structural deficiencies are seen as inhibiting its full maturation. RAND Corporation analyst Roger Cliff suggests that among these shortcomings is the lack of competition among major weapons producers in China, where "most sectors are dominated by a single major manufacturer that produces all of the weapons of a particular type."[298]

In 2009, the PRC's annual defense white paper identified a number of reforms oriented toward improving the quality of the country's S&T infrastructure. These reforms included "establishing a sound licensing system for weaponry and equipment research and production," in which China's non-defense sector is permitted to compete for R&D and production projects; "enhancing the basic capabilities of weaponry and equipment research and production," which encourages the informationization of weapon design and development; and "building a dynamic innovation system for defense-related science, technology and industry," in which the government has sought to foster a favorable environment for

293 See Mark Stokes, "China's Evolving Conventional Strategic Strike Capability," Project 2049 Institute Occasional Paper, September 14, 2009: http://project2049.net/documents/chinese_anti_ship_ballistic_missile_asbm.pdf

294 See Eric Hagt and Mathew Durnin, "China's Antiship Ballistic Missile," *Naval War College Review,* Autumn 2009, Volume 62, No. 4: http://www.chinasecurity.us/pdfs/others/Hagt&Durnin.pdf; see also Andrew S. Erickson and David D. Yang, "On the Verge of a Game-Changer," *Proceedings Magazine*, May 2009

295 Evan A. Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age*, Stanford University Press, 2003. p. 26.

296 "Project 640: China's National Missile Defence in the '70s," SinoDefence.com, April 11, 2009: http://www.sinodefence.com/special/airdefence/project640.asp

297 Bernard D. Cole and Paul H.B. Godwin, "Advanced Military Technologies and the PLA: Priorities and Capabilities in the 21st Century," in Larry M. Wortzel, ed., *The Chinese Armed Forces in the 21st Century*, Strategic Studies Institute, U.S. Army War College, December 1999: http://www.au.af.mil/au/awc/awcgate/ssi/chin21cent.pdf

298 Roger Cliff, testimony before the U.S.-China Economic and Security Review Commission hearing on "China's Military Modernization and U.S. Export Controls," March 16-17, 2006: http://www.uscc.gov/hearings/2006hearings/transcripts/march16_17/March_16-17_FINAL.pdf

S&T innovation by identifying, cultivating, and attracting talented scientific personnel to its defense industry research institutes and enterprises.[299]

In addition, China's university system appears to be playing a more prominent role in defense R&D. For certain civilian academic institutions, such as the Beijing University of Aeronautics and Astronautics (NUAA), Northwest Polytechnical University (NPU), and the Harbin Institute of Technology (HIT), this increased role is unsurprising. Qinghua University in Beijing also has been known to be a key player in basic defense R&D. However, the networks linking China's defense R&D community and traditionally civilian universities appear to be expanding significantly. For example, Xiamen and Sichuan Universities have been heavily involved in military opto-electronics R&D; Zhejiang University has been instrumental in developing KKV-related components; and Nanjing University has been granted R&D funding for specialized passive stealth coatings for re-entry vehicles.

As a means to increase innovation, the Chinese leadership is encouraging competition among lead systems integrators and contractors for sub-systems, sub-assemblies, and components. Effective last year, even private firms that lie outside the well-defined boundaries of China's defense industry can now compete for defense contracts. However, it remains open to question how many high-tech entities would voluntarily choose to enter the defense market. Defense industry writings are open in expressing preference for the civilian market due to more lucrative profit margins.

The best example of the new intermural competitiveness within China's defense industry may be the competition to satisfy a major PLA joint air-sea military requirement—the ability to strike U.S. aircraft carriers operating in the western Pacific. In 2002, a conceptual design study was completed by the leading division within the aerospace industry responsible for ballistic missile development. Later, Chinese cruise missile designers in a separate business entity published a series of technical articles demonstrating the feasibility of extended-range cruise missiles flying a modified high-altitude trajectory to strike large, slow-moving targets at sea. The tone and content of the articles—highlighting technical obstacles associated with ballistic missiles in countering aircraft carriers and emphasizing the utility of extended-range cruise missiles—demonstrate a competitive environment. Journals associated with the shipbuilding industry echoed the views of the cruise missile designers yet also published feasibility studies on the use of submarine-launched anti-ship ballistic missiles.[300]

Another strategy China is pursuing to improve its R&D system involves streamlining leading business divisions within the aerospace industry by spinning off lower-tier component and sub-assembly suppliers and reassigning them under separate, competing business divisions. At the sub-system and component level, competition now appears to exist in the design, development, and manufacturing of control and guidance packages and propulsion systems. A prime example is the 2008 formation of a new defense entity responsible for inertial measurement units, telemetry, and missile-related microelectronics, such as high performance digital signal processors and field programmable gate arrays that are needed for long-

[299] *China's National Defense in 2008*, Information Office of the State Council of the People's Republic of China, Beijing, January 2009: http://www.gov.cn/english/official/2009-01/20/content_1210227.htm

[300] See Guan Shiyi, "Diversification of Cruise Missile Development," (*duoyuanjihua fazhan de feihang daodan*), *Missiles and Space Vehicles* (*daodan yu hangtian yunzai huojian*), June 2002, pp. 20-27; Guan Shiyi, "New Concept Cruise Missile Based on a Qian Xuesen Trajectory" (*jiyu qian xuesen dandao de xin gainian feihang daodan*) *Winged Missiles* (*feihang daodan*), 2003(1); Song Fuzhi, "Countering Aircraft Carriers: Prioritize Cruise Missiles Over Ballistic Missiles," (*duikang hangmu – xunhang daodan youyu dandao daodan*), *Tactical Missile Technology*, April 2006; and Guan Shiyi, Zhu Kun, and Song Fuzhi, "Some Issues Regarding Cruise Missile Systems," *Tactical Missile Technology* (*Zhanshu daodan jishu*), May 2004, pp. 1-10. The authors in these articles are all from the CASIC Third Academy's cruise missile design and systems engineering department. For an argument against the use of cruise missiles and in favor of sea-launched ballistic missiles to counter aircraft carriers, see Wang Zaigang, "The Nemesis of Super Aircraft Carrier Battle Groups," (*chaoji hangmu jiandui de xingke*), *Jianchuan Zhishi*, January 5, 2005, pp 24-27.

range precision strike at high speeds and under extreme temperature conditions. In 2002, Chinese leaders directed the industry's solid motor academy to spin off a subsidiary, creating two competing divisions to vie for contracts related to solid propulsion systems, as well as restartable hybrid liquid-solid engines. The spun-off subsidiary—the new entrant to the defense market—reportedly raised private capital to cover R&D costs for a new solid motor to launch on-demand solid fueled launch vehicles.

Yet another means of overcoming R&D shortcomings and direct 863 Program technologies developed toward military applications is the creation of national-level expert working groups under the General Armaments Department (GAD). The ostensible purpose of these groups is to achieve technological breakthroughs that could be applied across a range of force modernization programs. Composed of members from industry, defense-related academia, and the civilian university system, the working groups report to the PLA GAD's S&T Committee, which is responsible for setting China's long-term defense R&D agenda. A number of experts within these groups also participate in 863 Program focus area expert working groups. Examples of individual PLA-managed technology working groups include: [301]

- General Missile Technology
- Precision Guidance Technology
- Computer and Software Technology
- Satellite Technology
- Radar Sensor Technology
- MEMS Technology
- Simulation Technology
- Stealth Technology
- Opto-Electronics Technology
- Aircraft Technology
- Target Characteristics and Signal Control
- Inertial Technology
- Acoustics and Acoustic Countermeasure Technology

Another seemingly new trend is restructuring the aerospace industry through the creation of new research institutes targeted at specific next generation military capabilities. The best example is the newly established 10th Research Institute (RI) under the China Aerospace Science and Technology Corporation (CASC). Also known as the Near Space Flight Vehicle Research Institute, the 10th RI is focused exclusively on designing and developing hypersonic flight vehicles that transit the upper atmosphere rather than adopting a traditional ballistic trajectory. This new institute does not appear to be academic in orientation. The 10th RI's director, who is cited as the chief designer of a major solid-fueled ballistic missile system, also heads the PLA/GAD General Missile Technology Expert Working Group and serves as deputy director of the PLA/GAD Precision Guidance Expert Working Group. While still

[301] The Precision Guidance Expert Group has been headed by Chen Dingchang, former CASIC Second Academy Director. See "Introduction to Chen Dingchang, at: http://www.casic.com.cn/n16/n1250/n10984/n17506/17672.html. Bao Weimin, Director of the CASC First Academy's new 10th Research Institute, serves as his deputy. Other key players in this group include Yao Yu, head of the Harbin Institute of Technology; Yin Xinliang, former Second Academy Director, CASIC Director, and currently Deputy Chairman of CASIC's S&T Advisory Group; Zhang Tianxu, an automatic target recognition expert from Huazhong S&T University's Institute for Pattern Recognition and Artificial Intelligence; and Zeng Guangshang from the CASC First Academy's 18th Research Institute. The 863-801 program appears to be aligned with the GAD Precision Guidance Experts Group, with Yao Yu for example serving on both the 863-801 and Precision Guidance Expert Groups. Another expert, Long Teng from Beijing Ligong University, also has been on the 863-801 expert group and also sits on the GAD Radar Surveillance Experts Group and Satellite Application Expert Group. He Songhua from Hunan University has been on a number of GAD Committees, with a particular focus on millimeter wave seeker technology, and also served as a consultant to the CASIC Second Academy's Second Design Department.

requiring further research, an initial survey of Chinese technical literature indicates the dedication of resources into developing a boost-glide flight vehicle that appears to be modeled after the U.S. Common Aero Vehicle (CAV) program. The establishment of a separate research institute within China's premier launch vehicle and ballistic missile academy that focuses on one capability indicates the priority senior civilian and military leaders have placed on next generation long-range precision strike vehicles.

The end result of these organizational shifts appears to be a defense R&D system that is more capable of informing and satisfying PLA operational requirements. An increasingly competitive environment involving contract tenders for major programs could help overcome generations of cultural conditioning that has stifled creativity and impeded major breakthroughs in the defense industry. A competitive environment could also create new dynamics in the PLA operational requirement development process.

Foreign-Educated Chinese

Since its national modernization effort began, a cornerstone of China's scientific knowledge base has been the expertise of Chinese educated in the former Soviet Union, the United States, Europe, and other centers of technological advancement. This reliance dates to the late 18th and early 19th centuries, when thousands of young Chinese were dispatched to receive foreign education and technical training, especially in the United States and Europe. One such individual was Deng Xiaoping, who is the subject of a revealing anecdote about Chinese perceptions of their status relative to the West at the time. As an adolescent set to depart for study in France in 1920, Deng is said to have been asked by his father what he hoped to learn in the West. Deng's response reflected a central tenet in the Chinese school curriculum of the day: "To learn knowledge and truth from the West in order to save China."[302]

Perhaps the most famous foreign-educated Chinese individual is Qian Xuesen, often referred to as the father of China's space program. Qian's 1955 deportation to China from the United State on suspicions of communist sympathies provided the PRC with inestimable scientific expertise. The founding director of the Jet Propulsion Center at the California Institute of Technology, Qian went on to establish the PRC's Institute of Mechanics and contributed heavily to the country's scientific advancement. According to Mark Stokes, Qian "passionately accepted the responsibility of leading the development of China's aerospace capability" and relied on two critical resources in doing so—a team of foreign-trained engineers he personally assembled and foreign technical materials to guide Chinese research.[303] The foundation Qian laid for China's ballistic and cruise missile, satellite, and aerospace programs contributed substantially to the nation's early achievements in these realms.

The PRC's cultivation of ethnic Chinese talent from abroad has accelerated in recent decades, as the state attempts to attract young, highly educated individuals back to China with financial inducements and patriotic appeals. As the economic and political atmosphere in the country has improved since the Tiananmen Square crackdown, this cohort of professionals, accustomed to the innovative culture and economic prosperity of the West, has found China increasingly promising. A recent media report highlighting the return of Western-educated scientists to China related that these individuals have come to dominate the PRC's National Institute for Biological Sciences (NIBS), which is described as "China's most successful research institution." Tellingly, each of the institute's 23 principal researchers, as well as its director and deputy director, were educated in the United States.[304]

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[302] Benjamin Yang, *Deng: A Political Biography*, East Gate Books, 1997. p. 28.
[303] Mark A. Stokes, *China's Strategic Modernization: Implications for the United States*, U.S. Army War College, Strategic Studies Institute, September 1999: http://www.fas.org/nuke/guide/china/doctrine/chinamod.pdf
[304] John Pomfret, "China pushing the envelope on science, and sometimes ethics," *Washington Post*, June 28, 2010: http://www.washingtonpost.com/wp-dyn/content/article/2010/06/27/AR2010062703639.html?hpid=moreheadlines

In December 2008, Chinese officials announced the launch of the "Thousand Person Plan" (*qianren jihua*), a government initiative to recruit top-notch professional talent to China from around the world.[305] The plan aims to attract 2,000 scientists, business leaders, and financial experts, especially holders of doctorates from prestigious foreign institutions, over the next decade.[306] Yet, a more sweeping and sustainable policy will necessarily involve solidifying the conditions that would make China hospitable for overseas Chinese talent. This talent pool includes the more than 100,000 Chinese citizens studying in the United States today,[307] as well as the 27,000 Chinese citizens who hold U.S. H1-B visas allowing them to work in the United States in highly specialized fields.[308] Like many foreign nationals studying or working temporarily in the United States and Europe, a substantial fraction of overseas Chinese jockeys to remain in these countries, often in perpetuity, depriving their developing home country of crucial human capital. China's leaders are certain to consider a range of policies designed to overcome the allure of a life in the West and return home to participate in the development of China. To be successful, these policies must address the sclerotic atmosphere in many Chinese laboratories, which discourages risk-taking and innovation. Peggy S. Christoff describes a stultifying effect of China's scientific culture, noting that "China's best and brightest scientists, tired of inappropriate intervention in their research and inadequate support for their programs, go outside of the system to live and work in other countries or, at the very least, seek employment at firms within China that do not engage in R&D requiring unencumbered scientific inquiry..."[309]

An even longer term campaign will seek to reduce the disparity between Chinese research institutes and universities and their foreign counterparts. While a handful of ethnic Chinese have won Nobel Prizes in the hard sciences, including several Chinese-American physicists, none has been honored for research conducted in the PRC.[310] China's lack of representation in the ranks of Nobel laureates has reportedly become something of a national obsession among Chinese scientists and political leaders.[311] Despite considerable improvements in quality since the end of the Cultural Revolution, China still operates a less than world-class university system. James Fallows, who described Chinese universities as emphasizing "volume of output over independence or excellence of research," notes that in a global ranking of the world's leading universities based on the number of scientific research papers produced, not one of the top 100 is located China.[312] Overcoming such institutional deficiencies will factor heavily in China's ability to produce indigenous high-technology advances in the economic and military realms.

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305 Michael Skapinker, "There are no easy answers to the call of home," *Financial Times*, August 3, 2009: http://www.ft.com/cms/s/0/f7b26a60-8057-11de-bf04-00144feabdc0.html?catid=136&SID=google

306 Hao Xin, "Help Wanted: 2000 Leading Lights To Inject a Spirit of Innovation," *Science*, Volume 325, Number 5940, July 2009.

307 Tamar Lewin, "China Is Sending More Students to U.S.," *New York Times*, November 16, 2009: http://www.nytimes.com/2009/11/16/education/16international-.html

308 Larry M. Wortzel, "Sources and Methods of Foreign Nationals Engaged in Economic and Military Espionage," Heritage Lecture #907, November 4, 2005: http://www.heritage.org/Research/AsiaandthePacific/hl907.cfm

309 Peggy S. Christoff, "China's Technology Sector," Federal Research Division, Library of Congress, September 2008: http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA509530&Location=U2&doc=GetTRDoc.pdf

310 Sharon LaFraniere, "Fighting Trend, China Is Luring Scientists Home," *New York Times*, January 6, 2010: http://www.nytimes.com/2010/01/07/world/asia/07scholar.html

311 Cong Cao, "Chinese Science and the 'Nobel Prize Complex,'" *Minerva*, Volume 42, Number 2, June 2004, pp. 151-172: https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/4816/Minerva-2004.pdf?sequence=1

312 According to Fallows, 17 of the top 20 universities are American, two are British (Cambridge and Oxford), and one is Japanese (the University of Tokyo). See James Fallows, "How America Can Rise Again," *The Atlantic*, January/February 2010: http://www.theatlantic.com/doc/201001/american-decline

SECTION 6: ACQUISITION AND DEVELOPMENT OF DUAL-USE TECHNOLOGY

The application of civilian technology to military use is a tradition with a rich pedigree in modern Chinese history, as is the reverse—developing military technology as part of a broader national scientific undertaking. The former practice was given Deng Xiaoping's official imprimatur in his guidance to senior PLA commanders in the early 1980s to "use the civilian to nurture the military" (*yimin yangjun*).[313] Later, party officials unveiled the "16-Character Policy" in 1997, a directive intended to foster mutually reinforcing relationships between China's military and commercial institutions. The instructions contained in the 16 characters translate literally as: "combine the military and civil" (*jun-min jiehe*); "combine peace and war" (*ping-zhan jiehe*); "give priority to military products" (*jun-pin youxian*); and "let the civil support the military" (y*i min yan jun*). While this guidance reflects a broad understanding that interactions between different sectors of the state can create beneficial synergies, Western analysts may have placed too much weight on the power of the pronouncement to explain recent high-level Chinese resource allocation. That is, the 16-Character Policy may represent nothing more than the official rhetorical embrace of an organic phenomenon rather than a centrally-driven approach to military and civil development.

Whatever its explanatory power, recognition of the policy's underlying logic has been evident among many Chinese leaders since the PRC's founding. Nie Rongzhen, director of China's original nuclear weapons program, understood that the pursuit of advanced military technology and the broader scientific development of the nation were not discrete pursuits but rather intertwined and mutually reinforcing efforts. Evan Feigenbaum suggests that this understanding produced a "military-led Chinese technonationalism" in which military research was "concerned not merely with strategic *weapons* but with strategic *technologies* of broader significance and scope." [Emphasis in original] These technologies, he writes, "impinged on industrial competitiveness, international standing, and economic power, not solely military strength."[314]

Given the diverse utility of many scientific innovations in both the civil and military realms, the pursuit of dual-use technology has for decades been a key feature of China's drive to advance its general scientific capabilities. Kathleen A. Walsh notes that China, like the U.S. defense establishment, is actively "seeking to exploit the ubiquitous nature of dual-use technology in a global economy."[315] The PRC's principal sources of dual-use technology, according to Tai Ming Cheung, are indigenous development, foreign acquisition (especially Russian military technology), outright purchases of Western companies, and joint commercial enterprises.[316]

Acquisition of U.S. Dual-Use Technology

Richard A. Bitzinger argues that Western industry has been a "critical supplier of investments and technologies that are helping China develop civilian high-tech sectors within its defense industry, which

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[313] Evan A. Feigenbaum. *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age*, Stanford University Press, 2003. p. 91.
[314] Feigenbaum, op. cit.
[315] Kathleen A. Walsh, testimony before the U.S.-China Economic and Security Review Commission hearing, "China's High Technology Development,"April 21-22, 2005: http://www.uscc.gov/hearings/2005hearings/hr05_04_21_22.php
[316] Tai Ming Cheung, "Will Technology Be a Source of Chinese Influence in Asia?" American Enterprise Institute/National Defense University conference, May 13, 2005: http://www.aei.org/EMStaticPage/1071?page=Summary

in turn could help underwrite the design and manufacture of sophisticated weapon systems."[317] Chief among China's high-tech suppliers is the United States, a sometimes willing and at other times reluctant target of PRC technology acquisition efforts. Ironically, U.S. leaders once played a central role in spurring their Chinese counterparts to build up the PRC's scientific infrastructure. With the 1979 signing of the *Agreement Between the Governments of the People's Republic of China and the United States of America on Cooperation in Science and Technology*, formal Sino-American relations were established in the realm of S&T. This agreement facilitated travel to the United States by Chinese scientists and is often credited with convincing China's leaders of the extent of their country's S&T backwardness, in part as a result of the Cultural Revolution.[318]

During the 1980s, as part of a policy to strengthen the PRC as a strategic counterweight to the Soviet Union, China was given access to a number of advanced U.S. systems. Jonathan Pollack describes technology transfers from the United States to China during this period as "pivotal" to the development of China's civilian industrial base. Pollack observes that the program "involved technologies and know-how with inherent relevance to both civilian and military programs."[319] The chill in Sino-American relations after the 1989 Tiananmen Square crackdown effectively brought this cooperation to a halt. In the following two decades, concern over China's controversial technology-gathering activities contributed to efforts to stanch the flow of U.S. dual-use technology to the PRC.

Shortly after the controversy surrounding China's alleged theft of U.S. nuclear weapons secrets, as well as a broader pattern of pursuing U.S. commercial technology for military purposes, the United States Congress created the U.S.-China Economic and Security Review Commission. The purpose of this body was to "review the national security implications of trade and economic ties between the United States and the People's Republic of China."[320] Implicit in the commission's charter was the concern that as part of the maturing economic relationship between the two countries, China would obtain, through commercial transactions, industrial espionage, and other methods, technologies that may be detrimental to U.S. national security. The 2007 report of the commission describes China's acquisition of a number of foreign dual-use technologies, including computers, software, semiconductors, communications products, and integrated circuits, which can fulfill both civilian and military purposes.

Among China's more legitimate technology acquisition strategies, perhaps the most transparent is to enter into commercial arrangements that explicitly require technology-sharing, which Chinese business representatives emphasize when negotiating agreements. According to the Commission's report, the "nature of the regulatory and commercial environment in China places enormous pressure on foreign companies…to transfer technology to Chinese companies as a part of doing business in China and to remain competitive globally."[321] Richard Suttmeier elaborates:

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[317] Richard A. Bitzinger, "Going Places or Running in Place? China's Efforts to Leverage Advanced Technologies for Military Use," in Susan M. Puska, ed., *People's Liberation Army After Next*, Strategic Studies Institute, U.S. Army War College, August 2000: http://www.strategicstudiesinstitute.army.mil/pdffiles/PUB67.pdf

[318] Richard P. Suttmeier, "From Cold War Science Diplomacy to Partnering in a Networked World: 30 Years of Sino-US Relations in Science and Technology," Earlier version presented at the 2009 Hixon Forum on "Science and Technology in the Making of Modern China," February 27-28, 2009: http://china-us.uoregon.edu/pdf/030409.pdf

[319] Jonathan D. Pollack, "The Cox Report's 'Dirty Little Secret,'" *Arms Control Today*, April/May 1999: http://www.armscontrol.org/act/1999_04-05/jpam99

[320] Floyd D. Spence National Defense Authorization Act for 2001 § 1238, P.L. No. 106-398 (codified at 22 USC § 7002 (2001)); § 7002. United States-China Economic and Security Review Commission: http://www.uscc.gov/about/charter.php

[321] *2007 Report to Congress of the U.S.-China Economic and Security Review Commission*, November 2007: http://www.uscc.gov/annual_report/2007/report_to_congress.pdf

> By the 1990s, China had developed increasingly sophisticated foreign investment regulations intended to extract as much technology as possible from foreign investors under its so-called 'market for technology' strategy. Although U.S. firms were not alone in transferring technology to China, in terms of scale and value of investments, levels of technology, and styles of corporate management, U.S. companies arguably have been the major source of foreign technology for China since the early 1980s, in spite of U.S. export control policies.[322]

This behavior was observed in the commercial space launch sector following the U.S. decision in the late 1980s to contract with China to hoist American telecommunications satellites into space using the PRC's Long March rockets. While U.S. authorities permitted these arrangements, American companies were forbidden from transferring sensitive technology to China without explicit government authorization. The animating concern was that U.S. technology could, in addition to aiding China's space launch vehicles, improve the performance of the country's inter-continental ballistic missiles (ICBMs). Nevertheless, Chinese authorities were persistent in their attempts to gain access to American technology as part of commercial arrangements with the United States.[323]

Unsurprisingly given this history, perhaps the most widely known instance of China profiting from American dual-use technology involves the case of Loral Space & Communications. In 1996, a launch failure occurred at China's Xichang launch center when a Long March 3B space launch vehicle attempting to launch the U.S.-manufactured Intelsat 708 telecommunications satellite crashed shortly after lift-off.[324] Following the rocket failure, an Independent Review Committee (IRC) was established to investigate its causes and report to the space launch insurance industry. Conclusions from the accompanying report, provided without authorization to the PRC state-run China Great Wall Industry Corporation, were characterized in the 1999 Cox report as having provided China with "exposure…to Western diagnostic processes, which could lead to improvements in reliability for all PRC missile and rocket programs." In 2002, Loral agreed to pay a civil penalty of $14 million and strengthened its program for compliance with technology export restrictions.[325] Also charged in connection with the incident was Hughes Electronics Corporation and Boeing Satellite Systems (formerly Hughes Space and Communications International), whose personnel participated in the IRC inquiry. Hughes and Boeing ultimately paid a $32 million fine for the export breach in 2003.[326] Quite apart from the controversy over providing technical assistance to the Chinese, reports later surfaced that encoded circuit boards were removed from the destroyed satellite before American technicians could examine the wreckage. During subsequent congressional hearings on the alleged technology theft, one lawmaker read a statement, purportedly from the U.S. National Security Agency, suggesting that "If the encryption board were reversed-engineered, the knowledge gained could be used to strengthen adversaries' knowledge" of sensitive U.S. communications systems.[327]

Today the U.S. Commerce Department's Bureau of Industry and Security (BIS) refuses to issue licenses for the sale of dual-use items and technology to China if the technology will "make a direct and

[322] Richard P. Suttmeier, "From Cold War Science Diplomacy to Partnering in a Networked World: 30 Years of Sino-US Relations in Science and Technology," Earlier version presented at the 2009 Hixon Forum on "Science and Technology in the Making of Modern China," February 27-28, 2009: http://china-us.uoregon.edu/pdf/030409.pdf

[323] John Mintz, "2 U.S. space giants accused of aiding China," *Washington Post*, January 1, 2003: http://www.sfgate.com/cgi-bin/article.cgi?file=/chronicle/archive/2003/01/01/MN153988.DTL

[324] *Report of the Select Committee on U.S. National Security and Military / Commercial Concerns with the People's Republic of China*, U.S. House of Representatives, January 3, 1999: http://www.house.gov/coxreport/; pp. 96-98.

[325] See "Loral and U.S. Government Settle 1996 Chinese Launch Matter," Loral Space and Communications press release, January 9, 2002: http://www.loralpresscenter.com/inthenews/020109.html

[326] Alec Klein, "ITT to Pay $100 Million Export Fine," *Washington Post*, March 28, 2007: http://www.washingtonpost.com/wp-dyn/content/article/2007/03/27/AR2007032702105.html

[327] Eric Schmitt, "A Secret U.S. Device Missing After '96 China Rocket Crash," *New York Times*, June 24, 1998.

significant contribution to the PRC's electronic and anti-submarine warfare, intelligence gathering, power projection, or air superiority."[328] However, considerable ambiguity exists over which commercial technologies might confer worrisome technical information to the Chinese. Consequently, there have been instances in which seemingly innocuous technology transfers to China, especially those occurring with the sale of American companies, have generated unease in the U.S. national security community.

In an analysis of the conditions under which Chinese acquisition of an American company might represent a threat to U.S. national security, Theodore Moran uses the Lenovo case to illustrate what he considers undue alarm over foreign purchases of U.S. corporations. In early 2005, several members of Congress requested the Committee on Foreign Investment in the United States (CFIUS), to investigate whether the proposed sale of IBM's personal computing division to the Chinese company Lenovo jeopardized U.S. national security; a subsequent security review determined that it did not, and the deal was allowed to proceed.[329] Moran argues that it was "far-fetched to think that Lenovo's acquisition of IBM's PC business represented a risk of 'leakage' of sensitive technology or provided China with military-application or dual-use capabilities that are not readily available elsewhere."[330] Nonetheless, according to Brookings Institution fellow Yuan-Kang Wang, PLA Major General Wang Baocun of the Academy of Military Science has suggested that the advancements made within China's information technology sector, typified by Lenovo, are "the key to mitigating the gap between the PLA and the armed forces of advanced countries," which can be closed by building an "informationized" (*xinxihua*) armed force.[331]

A more recent episode in which analysts have warned of China's potential to derive sensitive technology from a commercial transaction involves the Westinghouse nuclear deal. It must be noted, however, that the circumstances of this transaction have generated nothing like the controversy that surrounded Loral and Hughes. In 2006, a multibillion dollar deal was struck between Westinghouse Electric Company and the China National Nuclear Corporation to construct four AP-1000 civilian nuclear power plants in China, an arrangement that included the transfer of Generation III+ reactor technology.[332] According to various media reports, the technology transfer condition was apparently the deciding factor in choosing Westinghouse over France's Areva and Russia's AtomStroyExport.[333] In a proliferation analysis of the deal, analysts Stephen Mladineo and Charles Ferguson suggested that China could reverse-engineer advanced nuclear technologies acquired under the arrangement for military purposes. In particular, they argued, Chinese engineers could adapt the reactor coolant pumps in the AP-1000 for use in PLAN nuclear submarines, an adaptation that could make Chinese submarines quieter and thereby

[328] Peter Lichtenbaum, testimony before the House Armed Services Committee and the House International Relations Committee on the "EU Arms Embargo Against China," April 14, 2005: http://armedservices.house.gov/comdocs/schedules/Lichtenbaum41405.pdf. For a detailed discussion on U.S. policy concerning the export of arms to China, including software and technology designed for military applications, and commercial items that may have military applications, see "An E-mail Exchange Between the Department of Commerce and the Center for American Progress." March 27, 2005: http://www.americanprogress.org/issues/2005/03/b727703.html

[329] Steve Lohr, "Sale of I.B.M. Unit to China Passes U.S. Security Muster," *New York Times*, March 10, 2005.

[330] Theodore H. Moran, "Threat II: Leakage of Technology or Expertise to a Foreign-Controlled Entity," in *Three Threats: An Analytical Framework for the CFIUS Process*, Peterson Institute for International Economics, August 2009: http://bookstore.piie.com/book-store/4297.html

[331] Yuan-Kang Wang, "China's Grand Strategy and U.S. Primacy: Is China Balancing American Power?" The Brookings Institution, July 2006: http://www.brookings.edu/fp/cnaps/papers/wang2006.pdf

[332] Keith Bradsher, "Blessed by a U.S. Official, China Will Buy 4 Nuclear Reactors," *New York Times*, December 18, 2006: http://query.nytimes.com/gst/fullpage.html?res=9C06E4DC1331F93BA25751C1A9609C8B63

[333] Mark Hibbs, "China demanding AP1000 localization at record-breaking pace," *Nucleonics Week*, April 26, 2007.

confer "huge tactical and strategic advantages."[334] However, the enthusiastic advocacy for the Westinghouse bid by senior Bush Administration officials, including then Vice President Richard Cheney, Secretary of State Condoleezza Rice, and Secretary of Commerce Carlos Gutierrez, calls into question the extent to which this possibility alarms U.S. officials.[335]

While China has made concerted efforts to acquire advanced technology for ostensibly civilian purposes and then applied it to military capabilities, the reverse may also be true—obtaining military technology can also provide benefits to China's civilian high-technology infrastructure. Jonathan Pollack details one such arrangement in the 1980s in which U.S. technology acquired through an aircraft co-production agreement provided cascading benefits throughout a large sector of China's economy. Under an agreement with McDonnell Douglas initiated in 1985, China assembled MD-82 aircraft in Shanghai, which necessitated the provision of a "massive array of technical and design data." According to Pollack, the transmission of aircraft manufacturing expertise made possible by this arrangement "facilitated the skill base of the Chinese aviation industry as a whole, including the military sector."[336]

It stands to reason that as China continues to advance technologically, it will increasingly place a premium on acquiring and/or developing S&T capabilities that have applications in both civilian and military realms. First, this emphasis positions China to maximize its return on investment, benefiting both its military modernization effort and its national economic performance. Second, developing military capabilities through the exploitation of dual-use technologies allows China to increase its strength in a way that is least conspicuous, and therefore threatening, to its neighbors in the East Asian region, and especially the United States. Finally, and perhaps most importantly, mastering a diverse range of technologies delivers to China the status of being a truly advanced nation rather than one capable of achievements in only a limited set of fields.

[334] Stephen V. Mladineo and Charles D. Ferguson, "On the Westinghouse AP 1000 Sale to China and its Possible Military Implications," Nonproliferation Policy Education Center (NPEC) Research Memorandum, 2007: http://www.npec-web.org/Essays/20070311-MladineoFerguson-WestinghouseSaleToPrc.pdf

[335] **"**U.S.-Chinese Agreement Provides Path to Further Expansion of Nuclear Energy in China," U.S. Department of Energy press release, December 16, 2006: http://www.energy.gov/print/4536.htm; Yi-chong Xu, "Nuclear energy in China: Contested regimes," *Energy*, Volume 33, Issue 8, August 2008.

[336] Jonathan D. Pollack, "The Cox Report's 'Dirty Little Secret,'" *Arms Control Today*, April/May 1999: http://www.armscontrol.org/act/1999_04-05/jpam99

SECTION 7: CASE STUDIES IN TECHNOLOGY ACQUISITION

Case Study 1: Land Attack Cruise Missiles

Jeffrey Lewis, Ph.D.

A cruise missile essentially comprises two components: a propulsion system, such as a turbofan engine, and a guidance system. Cruise missiles date to the beginning of the missile age, but advances in propulsion and guidance have enabled the creation of highly capable Land Attack Cruise Missiles (LACMs) that can deliver large payloads over thousands of kilometers with great accuracy.

Chinese defense officials appear to place a high emphasis on developing conventionally armed LACMs to complement the PLA's growing stockpile of conventional short- and medium-range ballistic missiles. Cruise missiles offer Chinese defense planners several advantages. First, they can fly below the level of radar detection by air defenses and incorporate stealth technologies to further reduce radar and infrared signatures—technologies China is known to be integrating in its cruise missile inventory. Further, cruise missiles can also fly programmed trajectories. This characteristic allows them to overwhelm air defenses and hold at risk targets obscured by terrain. For example, Taiwanese air bases are defiladed behind mountains along the Pacific coast, making them difficult to target with a ballistic trajectory from the mainland.

The propulsion systems for long-range cruise missiles are essentially the same as those used in aircraft jet engines. Long-range cruise missiles with ranges in excess of 1,000 kilometers use relatively efficient "high bypass" turbofan engines not unlike those used by civilian airliners and some military aircraft. Chinese defense industries have long worked at developing domestically produced turbojet and turbofan engines, including "high bypass" turbofan engines for the J-10 fighter aircraft.[337] What truly distinguishes modern LACMs from older cruise missiles, however, is a relatively accurate guidance system that allows designers to extend its range significantly beyond 300 kilometers without a corresponding loss in accuracy. (The World War II-era V-1, for example, had a circular error probable that was more than 10 percent of its range—about 25 kilometers over 200 kilometers. A modern Tomahawk LACM, by contrast, has a circular error probable of a few meters over ten times that distance.) Although China has long maintained an arsenal of short-range cruise missiles (less than 300 kilometers), holding at risk targets across Taiwan requires Chinese designers to maintain accuracy at ranges in excess of 1,000 kilometers.

Modern guidance systems complement vastly improved inertial guidance systems with terrain contour matching (TERCOM), satellite navigation (e.g., GPS, GLONASS, and so on) and, in the terminal maneuver, optical scene matching. Thus, the dramatic improvement in cruise missile technology during the 1970s resulted not so much from improvements in propulsion but from enhancement of inertial navigation systems and the development of computer software allowing cruise missiles to navigate by

[337] Cruise-missiles using turbojet engines have achieved ranges in excess of 300 kilometers, as in the case of the SCALP-EG/Storm Shadow cruise missile manufactured by multinational European defense company MBDA.

digital maps.[338] Today, certain cruise missiles can use satellite navigation to achieve even better accuracy in flight.

Figure 1. Chinese DH-10 Land Attack Cruise Missiles on parade in 2009 (Xinhua News Service).

The DH-10: China's Land-Attack Cruise Missile

The U.S. National Air and Space Intelligence Center claims that China has two LACMs—the air-delivered YJ-63 and the ground-launched DH-10. (China maintains a much larger family of cruise missiles, including the well-known *Silkworm* missile.) The DH-10 is likely to form the backbone of China's LACM arsenal. The National Air and Space Intelligence Center estimates that the range of the DH-10 exceeds 1,500 kilometers.[339] Given this range—essential to holding at risk targets on Taiwan's eastern coast from Chinese missile bases—the DH-10 almost certainly employs a high-bypass turbofan engine, perhaps similar to the one developed for China's indigenous J-10 fighter aircraft.

The CASIC Third Academy's Third Design Department has overseen DH-10 design, development, and testing. With a supply chain that spans dozens of sub-contractors, low-rate initial production of LACMs began after final acceptance testing on both land- and air-launch variants in late July2003. LACM components, including engine, guidance, navigation, and control sub-systems, were assembled at the 159 Factory in Beijing's Fengtai District. The DH-10 is deployed on a three-tube road mobile launcher and approximately 100 LACMs enter in to the operational inventory each year.

Dates vary as to when China began developing a modern, long-range LACM. The United States first publicly acknowledged that China was developing cruise missile programs in 1997, when DoD informed

[338] See Eric V. Larson, *Technological Risk: The Case of the Tomahawk Cruise Missile*, Santa Monica, CA: RAND, September 1990: http://www.rand.org/pubs/papers/P7672/

[339] The previous edition of Chinese Military Power listed the range as in excess of 2,000 kilometers.

Congress that Chinese "land-attack cruise missiles (LACMs) for theater war-fighting and strategic attack… should be operational early in the next century."[340] Since 2006, China has deployed large numbers of the DH-10 LACM to Second Artillery brigades. There are also reports that China is developing an air-launched variant of the DH-10.[341]

China included a block of DH-10 launchers in its 2009 National Day Parade. Each launcher carries three tubes for missiles. By 2009, China had approximately 150-350 DH-10 missiles and 40-55 launchers.

Figure 2. From left to right: A possible Chinese DH-10 LACM; Pakistani Babur LACM, Russian AS-15 Kent (KH-55) LACM.

Externally, the DH-10 appears to resemble other LACMs, including Russia's AS-15 Kent (also known as the KH-55) and the U.S. Tomahawk Land Attack Missile (TLAM). It is difficult, however, to infer parentage from external dimensions. Pakistan's Babur cruise missile, for example, is externally identical to the AS-15 but has a considerably shorter range, likely owing to a less capable turbojet engine.[342]

There is relatively little open-source information available concerning the DH-10 guidance system. A "U.S. defense source" told *Defense News* investigator Wendell Minnick that the DH-10 is "likely to be equipped with an integrated inertial navigation system/Global Positioning System, supplemented by a terrain contour mapping system and digital scene-matching terminal-homing system able to provide a circular error probable (CEP) of 10m."[343] China has a variety of options should it wish to integrate satellite guidance, including its own domestic Beidou navigation system.

Chinese Acquisition Activities

China claims, not surprisingly, that the DH-10 is an indigenously designed cruise missile. Yet a significant amount of open-source information suggests that Chinese entities have pursued a variety of strategies to support indigenous cruise missile capabilities. These strategies include importing machine tools, acquiring cruise missiles for the purpose of reverse-engineering, and harnessing foreign expertise.

Some sense of the scale and scope of these activities can been seen in a variety of open-source accounts of Chinese efforts to acquire cruise missiles and relevant technologies.

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340 Report to Congress Pursuant to Section 1305 of the FY97 National Defense Authorization Act, April 2, 1997, p. 4.

341 Mark Stokes and Ian Easton, "Aerospace Trends in the Asia-Pacific Region: Implications for Stability in the Taiwan Strait and Beyond," Project 2049 Occasional Paper, May 27, 2010: http://project2049.net/documents/aerospace_trends_asia_pacific_region_stokes_easton.pdf

342 The National Air and Space Intelligence Center uses the same diagram to represent both the AS-15 and the Babur but lists the range of the AS-15 as more than 1,500 miles (more than 2,400 kilometers) and the range of the Babur as 200 miles (about 320 kilometers).

343 Wendell Minnick, "China tests new land-attack cruise missile," *Jane's Missiles & Rockets*, September 21, 2004.

- In 1991, China may have purchased from Russia a KH-55 cruise missile production line, staffed with Russian personnel. The assertion comes from a 1995 statement by Chong Pin Lin, later Taiwan's Deputy Minister of National Defense, in a Hong Kong newspaper, although he admitted "to date there is still no concrete evidence of it."[344]

- In 1995-1996, a state-owned aerospace company in China attempted to divert six machine tools licensed for export to China for joint production of the McDonnell Douglas MD-90 *Trunkliner* civilian aircraft to the Nanchang Aircraft Factory, which also manufactures military aircraft and cruise missiles. After McDonnell Douglas detected the diversion in early 1995, the Chinese firm shipped the machine tools to an appropriate facility in Shanghai by late 1996. Although the General Accounting Office (GAO) observed that "the equipment was relocated before it was misused," the attempted diversion of machine tools to a facility not involved in *Trunkliner* production is nevertheless troubling.[345] In particular, during the licensing process, the Defense Intelligence Agency noted that "the machine tools represented production capacity above and beyond the requirements for exclusive production of the 40 *Trunkliner* aircraft."[346]

- In 1999, *Newsweek* reported that China had acquired two U.S. Tomahawk cruise missiles from a 1998 strike on an al-Qaeda training camp in Afghanistan.[347] According to published reports, as many as six Tomahawk missiles landed in Pakistan, where they could have been used in Pakistan's Babur cruise missile program as well as made available to technicians from China and other countries.[348] A downed Tomahawk would have provided useful information about its propulsion system. Less clear is whether the guidance system could have been compromised. Tomahawk missiles reportedly contain software that scrambles sensitive information about the guidance system as a safeguard in the event that foreign militaries or intelligence agencies acquire a downed cruise missile.[349] This story is frequently repeated as fact, although a CIA spokesperson told the *Washington Post* in 2001 that "there has been no confirmation of a Chinese study of any such missiles."[350]

- China purchased six AS-15 Kent cruise missiles from Ukraine in 1999-2000. Ukrainian officials have also charged several Ukrainian individuals with illegally exporting 18 AS-15 Kent cruise missiles to Iran and China between 1999 and 2001.[351] (Iran received 12; China received six. The nature of their collaboration in this sale is unclear, but intriguing.) Ukrainian President Viktor Yushchenko publicly confirmed the transfer.

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[344] "Beijing, Russia Said Developing Cruise Missiles," Hong Kong LIEN HO PAO, FTS19970502000876 30; July 30, 1995.
[345] General Accounting Office, "Export Controls: Sensitive Machine Tool Exports to China," GAO/NSIAD-97-4, November 19, 1996: http://www.gao.gov/archive/1997/ns97004.pdf
[346] Ibid.
[347] John Barry and Gregory Vistica, "The Penetration Is Total," *Newsweek*, March 29, 1999.
[348] Mark Williams, "The Missiles of August—Part II: The Democratization of Cruise Missile Technology," *Technology Review*, August 29, 2006.
[349] Rick Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, Houghton Mifflin Company: 1993.
[350] Peter Finn, "Secret Tape Suggests China-Bin Laden Link; CIA Casts Doubt on Missile Technology Deal," *Washington Post*, October 20, 2001.
[351] The details are contained in a series of articles by the *Financial Times*, including: Tom Warner, "Ukraine sold cruise missiles to Iran, China," *Financial Times*, February 3, 2005; Guy Dinmore and Tom Warner, "Black market anxieties revived on Ukraine arms: Tom Warner on claims that missiles were sold to Iran and China," *Financial Times*, February 4, 2005; Tom Warner, "Ukraine admits exporting missiles to Iran and China" *Financial Times*, March 18, 2005; Tom Warner, "Ukraine probes fate of nuclear arsenal," *Financial Times*, March 23, 2005; and Tom Warner, "Russian accused in arms deal extradited," *Financial Times,* February 3, 2006.

- Between 2003-2005, Chinese officials paid American engineer Noshir Gowadia approximately \$110,000 to assist in reducing the infrared radar signature of a PRC cruise missile.[352] It is possible—though there is no public evidence—that Gowadia was working on the DH-10.[353] Gowadia analyzed methods to reduce the infrared signature from the exhaust nozzle, as well as the vulnerability of the cruise missile to the U.S. AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM). U.S. officials arrested Gowadia in October 2006.

- In 2005, Ko-Suen "Bill" Moo, a Korean-born Taiwanese national who is believed to have worked for the PRC, inquired about purchasing an F-16 engine and air-to-ground missiles, including the AIM-120 AMRAAM and AGM-129 Advanced Cruise Missile, from an undercover FBI agent. Moo explained that "the Chinese government had been dealing with Russia for the procurement of needed products [but] China is trying to find other avenues in which to produce these items, as it does not necessarily trust Russia."[354]

The array of acquisition strategies makes it difficult to assess the relative impact of any particular approach to the overall success of China's LACM programs. By examining the evolution of China's acquisition activities, as well as the timeline for China's DH-10 program, some educated guesses can nonetheless be made about how the PRC has developed its cruise missile programs. It appears, for instance, that China either did not acquire an AS-15 production line and staff from Russia in 1991 or that such assistance was of relatively minimal value. Had China done so, DH-10 like missiles might have been expected to appear significantly before deployment in 2006. Nor, had China acquired a useful production capability, should China have sought to acquire KH-55 cruise missiles from Ukraine. Conversely, China's successful effort to acquire Ukrainian cruise missiles, as well as Moo's unsuccessful effort to acquire a U.S. ACM, suggests that China likely attempted to acquire the six "clobbered" Tomahawk missiles that supposedly ended up in Pakistan. Moo told undercover agents, in attempting to acquire air-to-air and air-to-ground missiles, that "that Israel has sold China some of these missiles, but that China wants more and is willing to pay any price."[355] Absent Pakistani or Chinese confirmation, it is probably impossible to confirm whether Chinese personnel accessed the missiles or whether the downed missiles survived intact to provide useful information. However, these outcomes cannot be ruled out.

Yet reverse-engineering is not a straightforward process. Although Chinese technicians would have broken the missiles down to their components and recreated such blueprints, successfully producing duplicates would require integrating to domestically manufactured components, a process that depends upon developing a cadre of trained personnel possessing extensive knowledge developed from hands-on experience.[356]

Given the timeline of PRC efforts to acquire foreign cruise missiles and subsystems, the acquisition of six AS-15 LACMs from Ukraine seems to coincide with a turning point in China LACM program. It is possible that the AS-15 cruise missiles helped the Chinese solve certain problems relating to turbofan engines. (China's DH-10, with a reported range in excess of 1,500 kilometers, has considerably shorter range than the AS-15, which can carry a similar sized payload to twice that distance.) Although efforts to

[352] *United States of America v. Noshir Gowadia, Second Superceding Indictment*, Cr. No. 05-00486 HG-KSC.
[353] "Leaky Stealth," *Aviation Week and Space Technology*, December 17, 2007.
[354] *United States of America v. Ko-Suen Moo*, Cr. No. 05-3392 STB, p. 4.
[355] *United States of America v. Ko-Suen Moo*, Cr. No. 05-3392 STB, p. 16.
[356] Dennis Gormley, *Missile Contagion: Cruise Missile Proliferation and the Threat to International Security*, Praeger: 2008.

procure entire foreign systems seem to have continued, China's LACM program appears to have reached a stage of technology maturity in the 2003-2005 timeframe.

Perhaps most interesting in this period is the use of foreign technical personnel, as in the case of Noshir Gowadia, to consult on existing cruise missiles. Although Gowadia's work focused on an incremental improvement in reducing the infrared signature of a Chinese cruise missile, and increasing its survivability against U.S. air-to-air missiles, Chinese officials appear to have provided Gowadia with significant amounts of design information, including "system requirements and nozzle data for the real PRC cruise missile" which, in turn, was compromised by his arrest.[357]

[357] *United States of America v. Noshir Gowadia,* Second Superseding Indictment, Cr. No. 05-00486 HG-KSC., p. 17: http://www.fas.org/irp/ops/ci/gowadia.pdf

Case Study 2: Hit-to-Kill Technology

Jeffrey Lewis, Ph.D.

Although commentators have paid significant attention to China's interest in ASAT and ABM capabilities, these are missions that can be accomplished through a variety of technologies. Less attention has been paid to China's interest in a specific technology that enables both highly capable ASATs and ABMs—the development of so-called "hit-to-kill" or kinetic kill vehicles (KKVs).

During the Cold War, the United States and the Soviet Union pursued a variety of technologies to extend air defenses to counter ballistic missiles and satellites. However, the resulting systems were relatively ineffective until advances in information technology permitted the first kill vehicles capable of destroying fast-moving target with kinetic energy—"hitting a bullet with a bullet" in one colorful phrase.

Hit-to-kill technologies depend on a variety of modern technological achievements, including tracking systems, seekers that use visible "light" or infrared energy to find the target, attitude determination and control systems, and precision thrusters that bring the kill vehicle into contact with the target. Early efforts at developing a first-generation KKV culminated in the Army's successful 1984 test of the Homing Overlay Experiment, the first successful demonstration of hit-to-kill technology against a ballistic missile.

Recent focus on China's development of ASAT and ABM capabilities obscures Beijing's desire to develop hit-to-kill systems analogous to modern U.S. ABM programs rather than replicating first generation Soviet systems such as nuclear-tipped ABMs or co-orbital ASATs. As a result, Chinese acquisition strategies reflect a desire to develop indigenous capabilities that draw from, but are not dependent on, foreign assistance.

China's Hit-to-Kill System

China appears to have developed a small KKV for use with a modified solid-fueled ballistic missile, derived from the DF-21 or DF-31, against satellites and ballistic missiles. China has tested this system a handful of times in both ASAT and ABM mode, in addition to any modeling and simulation in the laboratory. According to the *New York Times*, the U.S. intelligence community detected at least two "flyby" tests of the system in which the interceptor did not strike a target:

- **July 2005.** The first test detected by the U.S. intelligence community.
- **February 2006.** The second test occurred close to a Chinese satellite, generating speculation about whether China had attempted a "fly by" or simply missed its target in a genuine test.[358]
- **January 2007 ASAT Test.** The first two tests did not become public knowledge until China conducted a third test against an aging FY-1C weather satellite in January 2007, creating an enormous amount of debris.[359]

[358] The first two tests are described in Michael R. Gordon and David S. Cloud, "U.S. Knew of China's Missile Test, but Kept Silent," *New York Times*, April 23, 2007: http://www.nytimes.com/2007/04/23/washington/23satellite.html

[359] For a detailed analysis of this test, as well as the decision-making leading up to it, see Gregory Kulacki and Jeffrey Lewis, "Understanding China's Antisatellite Test," *Nonproliferation Review* 15:2 (July 2008), pp. 335-347. See also Ashley Tellis, "Punching the U.S. Military's 'Soft Ribs': China's Antisatellite Weapon Test in Strategic Perspective," *Policy Brief*, Number 51, June 2007: http://www.carnegieendowment.org/publications/index.cfm?fa=view&id=19317; Ian Easton, "The Great Game in Space: China's Evolving ASAT Weapons Programs and Their Implications for Future U.S. Strategy," Project 2049 Institute Occasional Paper, June

- **January 2010 Missile Defense Test.** In January 2010, a Pentagon spokeswoman confirmed that the United States had "detected two geographically separated missile launch events with an exoatmospheric collision also being observed by space-based sensors."[360]

It seems likely that the January 2010 test involved the same system that had been used in the January 2007 test, though in a different mode. According to one Chinese account, which cannot be verified, the test of the KKV in an ASAT mode was an interim goal on the route to the more challenging mission of intercepting ballistic missiles.[361] Intercepting a ballistic missile is a technically more difficult task than destroying satellites, which move along a fixed track at a constant speed. "Satellite interception is like shooting a beer bottle. Missile interception is like shooting ducks," retired People's Liberation Army General Xu Guangyu explained to the *South China Morning Post*.

American officials have referred to the earlier Chinese test vehicle as the SC-19, which would suggest the 19th missile type launched from Jiuquan Space Center (also known as Shuang Cheng Tzu). Most open-source speculation centers on a modified DF-21 missile, though the last test may have used a different launcher.

The kill vehicle appears to use a mid-infrared seeker in the 3-5 micron range, similar to the U.S. Terminal High Altitude Area Defense (THAAD) ballistic missile defense system. According to the Chinese account discussed above, the mass of the kill vehicle itself is only 35 kilograms.[362] The geometry of the two successful tests suggests China used the sun to warm the target to enhance its visibility to the seeker.

Chinese Acquisition Activities

China's decision to develop an indigenous hit-to-kill system reflects the relatively high priority its leadership has given to developing capable air defenses. From the late 1950s, China aggressively pursued domestic variants of foreign air defenses. Initially, Chinese interest appears to have been driven by a combination of national neuralgia about sovereignty—overflights of the mainland were particularly galling to Beijing—and a desire to match the sophisticated capabilities of major powers like the United States and the Soviet Union. As a result, China initiated a number of very ambitious air defense programs, many of which failed spectacularly. Over time, however, China has developed a competent indigenous hit-to-kill capability, supplemented with the acquisition of foreign systems. There is little evidence in the public domain that espionage contributed directly to such programs. As we will see in the case of a Chinese technical delegation that visited the United States in 1998, many of the enabling technologies are openly available from the commercial and civilian research sector.

24, 2009: http://project2049.net/documents/china_asat_weapons_the_great_game_in_space.pdf; and Bates Gill and Martin Kleiber, "China's Space Odyssey," *Foreign Affairs*, 86:3 (May/June 2007) pp. 2-6.

[360] "Pentagon Received No Warning of Chinese Missile Defense Test," *Global Security Newswire*, January 12, 2010: http://gsn.nti.org/gsn/nw_20100112_1311.php

[361] See "我国"陆基中段反导拦截技术试验"初步分析," January 12, 2010. The author, who publishes under the pseudonym KKTT, participated in a discussion of his analysis at: http://www.armscontrolwonk.com/2666/chinas-kinetic-kill-vehicle. Available at: http://bbs.tiexue.net/post_4036553_1.html. For Western analysis of the KKTT post, see *China's Successful Anti-missile Test*, International Institute for Strategic Studies Strategic Comment, February 2010. Available at: http://www.iiss.org/publications/strategic-comments/past-issues/volume-16-2010/february/chinas-successful-anti-missile-test/ and "China's Missile Defense Interceptor Program: An Independent Chinese Analysis," *TaiwanLink*, January 17, 2010. Available at: http://thetaiwanlink.blogspot.com/2010/01/chinas-missile-defense-interceptor.html

[362] See note 347. KKTT explained on the blog *Arms Control Wonk* that the information was taken from the curriculum vitae of a Chinese Academy of Launch Technology designer, which has since been removed from the website. See http://www.armscontrolwonk.com/2666/chinas-kinetic-kill-vehicle

Indigenous Research

Although Chinese research and development efforts in the 1960s focused on so-called "sophisticated technologies" like nuclear weapons and ballistic missiles, the development of highly capable air defenses based on the Soviet SA-2 surface-to-air missile (SAM) and its associated radar systems was a close second in terms of priority for early Chinese weaponeers.[363] The Chinese produced an indigenous version of the SA-2 called the HQ-1. The PRC placed significant priority on modifying the HQ-1 to shoot-down U2 high-altitude reconnaissance aircraft operated by Taiwan during the 1960s. Chinese weaponeers created the HQ-2, a larger version of the HQ-1, which was capable of negating the U2's high altitude and electronic countermeasures. Before the program was terminated in 1974, China succeeded in downing at least four U2 aircraft, one of which is displayed in the Beijing Military museum. China also authorized the development of another missile, the HQ-3, to target the U.S. SR-71 aircraft, but flight-testing was unsuccessful.[364]

Figure 3. Wreckage of a U2 Aircraft with ROC markings in the Beijing Military Museum.
Source: http://www.flickr.com/photos/potenzh/577343786/

Given the priority of developing sophisticated air defenses, it is not surprising that China also conducted a program to expand China's defenses against ballistic missiles and surveillance satellites. The 640 Program, initiated by Mao Zedong during a period of increasing acrimony with the Soviet Union and the United States, examined a variety of missile defense and ASAT applications.[365]

[363] On the priority given to air defense efforts, see Nie, *Inside the Red Star: The Memoir of Marshall Nie Rongzhen*, pp. 704-705.
[364] On China's development of the early HQ series of SAMs, see *China Today, Defense Science and Technology*, pp. 456-489.
[365] "Project 640: China's National Missile Defence in the 1970s," Sinodefence.com, April 11, 2009: http://www.sinodefence.com/special/airdefence/project640.asp

- China developed a series of prototype-ABM interceptors (called *Fanji* or "Counterattack") that were flight tested during the 1970s. The missile appears to more closely resemble the U.S. Sprint system than it does the contemporary Soviet Galosh ABM interceptor (see below). China probably intended to use nuclear armed-interceptors, as the U.S. and Soviet systems did, relying on nuclear weapons to compensate for inaccuracy. Yet there is no indication that China developed or tested such devices.[366]

Figure 4. From left to right: Chinese Fanji, US Sprint, Russian Galosh ABM interceptors.

- China also developed a "super gun" similar to the U.S.-Canada High Altitude Research Program (HARP) called *Xianfeng* (or "Pioneer"). The HARP program built a prototype gun that fired a rocket that could be used to intercept missiles or satellites.

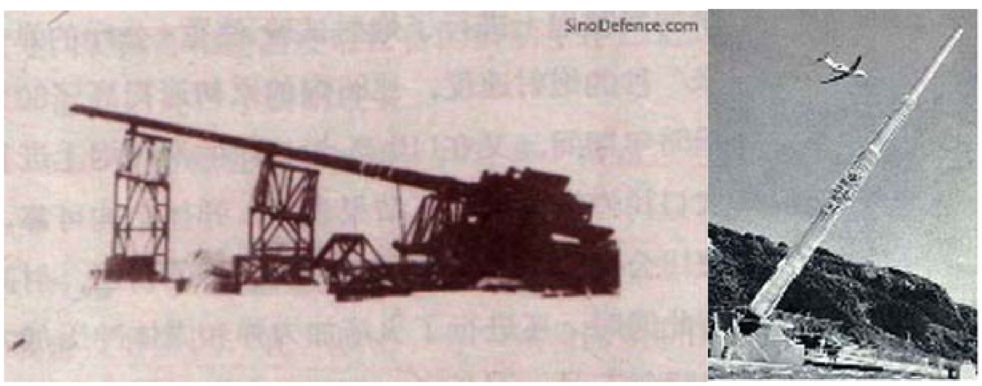

Figure 5. Possible Chinese "supergun" (left) and U.S. Project HARP gun (right). Photo credits: Sinodefence.com, Peter Millman.

- Some sources indicate that China also developed a pair of phased array radars, as well as a monopulse tracking radar as part of nationwide early warning network.[367] It is unclear how effective this system ultimately was, though it appears that some assets were integrated into China's space tracking, command and control network after the cancellation of Project 640. (China's Phased Array Radars were apparently abandoned in the early 1990s.)

China's indigenous efforts met with mixed results. Although China succeeded in developing HQ-2 missiles, Chinese efforts to develop counterparts to Sprint or HARP were unsuccessful. Ultimately,

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[366] China did develop an enhanced radiation device in the early 1980s that might have served as the basis for an ABM interceptor, but impetus of a so-called "neutron bomb" appears to have begun around the time that the ABM interceptor was winding down.
[367] "Project 640: China's National Missile Defence in the 1970s," Sinodefence.com, April 11, 2009: http://www.sinodefence.com/special/airdefence/project640.asp

Project 640 was deprioritized in 1978 as part of a broader realignment of defense priorities that occurred under Deng Xiaoping.[368]

Chinese interest in developing these capabilities revived with President Ronald Reagan's 1983 speech announcing the Strategic Defense Initiative (SDI), a multibillion dollar spaced-based system envisioned to shield the United States from ballistic missile attack. The speech resulted in a well-documented "high technology push" within China called Project 863. The project took its name from the 1986 date of a letter to Deng suggesting that China respond to SDI with an across the board investment in civilian and military high technology efforts from lasers to manned space flight.[369] Project 863 included a revival of work on technologies relevant to ASAT/ABM missions, including kinetic kill interceptors. Indeed, some reports suggest that the Chinese ASAT/ABM program was designated 863-409.

Overall, China's development of ASAT and ABM technologies—in particular, hit-to-kill systems—closely follows the technical lead of the United States. Further evidence suggesting of this hypothesis is the Chinese literature on these subjects, which appears largely devoted to following developments in the United States.[370]

China's new wave of investment resulted in the development of technologies needed for hit-to-kill systems, including "closed-loop fiber-optic gyroscopes, binary optical/mid-wave infrared seekers, restartable altitude/orbital control systems and thrust controls."[371] According to one Chinese account, these technologies matured in the late 1990s with a "suspension" test of a kinetic kill vehicle in 1999. Another account suggests that across the board spending increases in 1999 allowed the program to reach maturity by the mid-2000s, when China began flight-testing its KKV.[372]

Foreign Systems Acquisition

Over the same period that the PRC has invested considerable domestic resources, if episodically, in developing the ability to target ballistic missiles and satellites, China has also continued to improve the HQ series of missiles to hold at risk targets at medium and high altitudes.

PLA Surface-to-Air Missiles (SAM)		
Chinese or Russian Designation	**NATO Designation**	**No.**
HQ-2	CSA-1 and variants	400
HQ-6	CSA-2	30
KS-1A		60
HQ-9		64
S-300PMU	SA-10B GRUMBLE	32
S-300PMU1	SA-20 GARGOYLE	64
S-300PMU2	SA-20 GARGOYLE	32
Chinese Military Power, 2009		

368 John Lewis and Xue Litai, *China's Strategic Seapower: The Politics of Force Modernization in the Nuclear Age,* (Stanford University Press, 1996) p. 182.

369 This letter is described, as well as the effort to place it in Deng's hands, in Gregory Kulacki and Jeffrey G. Lewis, "A Place for One's Mat: China's Space Program, 1956–2003," American Academy of Arts and Sciences, The Reconsidering the Rules of Space Project, 2009: http://www.amacad.org/publications/spaceChina.pdf

370 Gregory Kulacki, "Anti-Satellite (ASAT) Technology in Chinese Open-Source Publications," *Union of Concerned Scientists*, July 1, 2009: http://www.ucsusa.org/assets/documents/nwgs/Kulacki-Chinese-ASAT-Literature-6-10-09.pdf

371 See note 4.

372 Lewis and Kulacki, *Understanding China's Antisatellite Test*, 2008.

In addition to long-standing efforts to develop domestic surface-to-air missiles, China appears to have purchased advanced Russian air defense missiles that are increasingly capable of performing limited ABM missions and likely provide some technological crossover to the KKV program:

- S-300/HQ-9. Since the late 1990s, China has purchased Russian surface-to-air missiles, including the SA-10 and SA-20. China now produces a domestic air-defense missile that incorporates SA-10 and SA-20 technologies described as the HQ-9, which the Chinese People's Liberation Army Air Force (PLAAF) displayed in the most recent October 1 military parade (see image). Slight differences in the phased-array radar, missile canisters and jet vanes confirm domestic Chinese production of the S-300.[373]

Figure 6. Chinese HQ-9 surface-to-air missile. Photo credit: China Defense Blog.

- S-400/HQ-19. There are also reports that China has purchased the SA-21 Growler (S-400) from Russia and has begun to produce a domestic variant called the HQ-19. Jane's Strategic Systems describes it as a "joint development programme with China."[374] Yet other reports suggest Russia had not yet completed any deals to export the S-400, though Belarus, Saudi Arabia, and China are potential customers.[375] Reports that China has purchased the S-400 seem premature at this point, although one would expect China to be an early customer. References to the missile as the HQ-19 may relate to the use of SC-19 by U.S. officials to describe the DF-21 launched KKV.

Foreign Technology Acquisition

Finally, China has openly attempted to acquire commercial, off-the-shelf technology that can be used in defense programs. As a former U.S. defense official explained to *Defense News*, "[The Chinese] don't necessarily 'steal' technology. They go in the front door and ask for advice from U.S. and presumably

[373] http://www.china-defense-mashup.com/?p=2635

[374] "S-400," *Jane's Strategic Systems*, 2006, pp.

[375] David C Isby, "Russia faces problems in marketing the S-400," *Jane's Missiles & Rockets*, October 27, 2009.

other countries' civilian academic institutions. Not too much that's sneaky about it."[376] For example, a technical group from the China Aerospace Science and Industry Corporation, working on Kinetic Kill Vehicles, attended an annual International Society for Optics and Photonics (SPIE) meeting in Florida in 1998.[377] According to a trip report, posted online, the delegation toured a number of facilities seeking help with technical issues related to the development of Kinetic Kill Vehicles, including diamond coating to space-qualify certain components.[378]

[376] Wendell Minnick, "China Missile Test Has Ominous Implications," *Defense News*, January 19, 2010: http://www.defensenews.com/story.php?i=4460204

[377] See, for example, Wan Ziming, "Calculating models of cooling IR window and window background radiation," *Proc. SPIE* 3375:195 (1998) pp. 195-202.

[378] See, for example: 美国SPIE'98气动光学会议介绍及相关技术考察, 航天技术与民品1999年第5期. Available at: http://www.space.cetin.net.cn/docs/mp9905/mp990513.htm. I am indebted to Mark Stokes for pointing out this document.

Case Study 3: Adaptive Optics for High Energy Laser Applications

Jeffrey Lewis, Ph.D.

China's development of high-powered lasers, and in particular adaptive optics, which allows the focusing of those beams through the turbulent atmosphere, differs from programs to develop cruise missiles and hit-to-kill technologies. In those cases, specific defense industries were involved in outlining key technologies that needed to be acquired in order to produce specific capabilities. In the case of adaptive optics, however, the Chinese government appears to have concluded that a broad range of directed energy technologies are important to maintaining the country's scientific and technological capabilities. As a result, much of the funding to China's directed energy research is essentially civil or commercial but easily converted to specific military capabilities, such as lasers that can track, dazzle, and perhaps blind U.S. reconnaissance satellites.

Adaptive optics is a key enabling technology to render laser and other directed energy capabilities into weapons systems that can hold at risk aircraft, missiles in flight, and satellites.[379] "Adaptive optics" refers to the capability to compensate for atmospheric distortion, for example by using a deformable mirror, and allow a beam of energy to remain focused.

China's development of adaptive optics has been largely indigenous, directed by a state-run program of grant-making to multiple institutions. There may be some economic espionage, as would-be grant recipients attempt to position themselves to receive state-funding. But on the whole, the program is designed to create indigenous capabilities, which can later be spun off into commercial or military applications.

The 863 Program

Much of China's investment in adaptive optics technologies occurs under the auspices of the 863 Program, a government-led effort to encourage the development of advanced technologies in China.[380] This program has its roots in Ronald Reagan's March 23, 1983, speech announcing SDI. Although Reagan did not mention China, his remarks touched off a debate within the PRC about the role of science and technology in China's national development. The result of Reagan's speech was a series of meetings organized by the leaders of various related government agencies, industrial departments, and research institutes on how China should respond to the challenge implicit in Reagan's speech. Some Chinese scientists argued that missile defense "is not just a military program but a far-reaching political striving to preserve American superiority" and that the American program's "real objective" was "to push forward new advanced technologies and national economic development."[381] These scientists argued that China must respond with a high-tech initiative of its own. Others, however, believed that China should continue with modest technology projects that would yield more immediate results and defer making large investments in cutting edge technologies.

The decisive event was a letter, dated March 3, 1986, signed by four senior Chinese scientists who strongly believed that China must launch its own drive to acquire high technology and therefore made an

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[379] For a brief summary of the development of adaptive optics in the United States for defense applications, see Ann Finkbeiner, *The Jasons: The Secret History of Science's Postwar Elite,* Viking: 2006. pp. 154-167, 243-245.

[380] Much of the following description of the 863 Program is drawn from: Gregory Kulacki and Jeffrey G. Lewis, "A Place for One's Mat: China's Space Program, 1956–2003," American Academy of Arts and Sciences, The Reconsidering the Rules of Space Project, 2009: http://www.amacad.org/publications/spaceChina.pdf and Evan A. Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age*, Stanford University Press, 2003.

[381] Kulacki and Jeffrey G. Lewis, 2009.

end-run around the bureaucracy. Wang Daheng, Chen Fangyun, Wang Ganchang, and Yang Jiachi were veterans of China's nuclear weapons program. They drafted a formal proposal, *Recommendations Concerning Research to Keep Pace with Foreign Strategic High Technology Development*, and as veteran bureaucrats, succeeded in placing the proposal directly in Deng Xiaoping's hands to circumvent a complacent bureaucracy. The four scientists argued that China's current course in the mid-1980s—emphasizing light industry, land reform, and basic economic development—was not enough to ensure the country's ability to continue to compete in a world where the advanced industrial nations were making a concerted effort toward new technologies.

Another split emerged during the first few days of the discussion between experts who wanted any high-technology initiative to be focused on military capabilities and others who argued for a broader approach targeting the development of the civilian economy. Ultimately, Deng Xiaoping intervened, expressing his opinion that they should pursue dual-use technology, with civilian applications as the primary focus. The central leadership subsequently approved the 863 Program—in reference to the March 1986 date of the four scientists' letter and Deng's commentary—and authorization for the expenditure of 10 billion RMB—about one-half of China's annual defense budget in 1986. This model of state-directed investment in key technologies continues to dominate China's drive to acquire the most advanced technologies. (For further discussion of the 863 Program, see Case Study: Hit-to-Kill Technology above.)

The 863 Program is fundamentally intended to develop indigenous capabilities. It provides a competitive process for awarding research funding in areas identified by China's leadership. Nevertheless, in some cases the competitive pressure created by the 863 program may result in individuals engaging in economic espionage to enhance their prospects of receiving state funding. For example, in 2007, a federal grand jury in California indicted two men, Li Lan and Ge Yuefei, on two counts relating to the theft of trade secrets from a U.S. and a Taiwanese company. The defendants allegedly intended to use the information to set up a business that would be partially funded out of the 863 account. Overall, however, the model is to develop China's scientific and technological base first and consider applications second.

Adaptive Optics Research Today

A significant enabling technology for strategic applications of directed energy are so-called "adaptive optics"—the ability to use deformable mirrors to correct for atmospheric disturbances. The United States developed this technology in the 1980s as part of the SDI research program.

Chinese research on adaptive optics began in 1979.[382] China established the Institute of Optics and Electronics (IOE) of Chinese Academy of Sciences in 1980. Today, the IOE hosts three "State Key Laboratories," two of which appear largely or entirely funded under Project 863—the *China State Key Laboratory for Beam Control for 863 Program* and the *China State Key Laboratory of Adaptive Optics for 863 Program*.[383] The Adaptive Optics Laboratory has research teams working on inertial confinement fusion, a cutting edge technology with applications to stockpile stewardship activities for China's nuclear weapons program and adaptive optics applications that could support research enabling China to track, range, and image satellites.

[382] For a general review of the development of adaptive optics in China, see Jiang Wenhan and Ning Ling, *Adaptive Optics in China*, Proc. SPIE, Vol. 3749, 56 (1999).

[383] See, for example, the website maintained by the Institute for Optics and Electronics: http://english.ioe.cas.cn/rh/rps/200912/t20091210_48339.html

IOE works closely with other Chinese Academy of Sciences research organizations, many of which also receive 863 funding, including the Anhui Institute of Optics and Fine Mechanics (or Precision Mechanics), Dalian Institute of Chemical Physics, Shanghai Institute of Optics and Fine Mechanics, Beijing Astronomical Observatory, Yunnan Astronomical Observatory, and the China Academy of Engineering Physics. This work is conducted in collaboration with international partners.

Possible Parallel Military Program

Unlike in the previous case studies on Land Attack Cruise Missiles and hit-to-kill technologies, where interest in military capabilities drove the acquisition of discreet technologies, in the case of adaptive optics general research appears to provide a broad base of support for a variety of applications, from civil to military missions. China, for example, has a large satellite laser ranging network that participates in international laser ranging activities.[384] Chinese scientists have examined adaptive optics techniques for laser ranging at the Kunming SLR Station.[385]

There is nothing inherently suspect about laser ranging, though such technologies could be applied to weapons programs. In September 2006, Vago Muradian of *Defense News* quoted "sources" claiming that "red high-power lasers at U.S. spy satellites flying over its territory in what experts see as a test of Chinese ability to blind the spacecraft." Eventually, U.S. officials confirmed that American satellites had experienced degraded performance when passing over China due to energy directed against them from the ground.[386]

U.S. officials confirmed that a space situational awareness asset at Kwajelein was able to detect that the energy was emanating from Chinese territory. In particular, the source of the energy did not appear to be satellite laser ranging facilities, well-known to the United States.

The Chinese could have a number of motives for illuminating a satellite in peacetime: to image the satellite, to assess its precise position by ranging, or to dazzle or blind the satellite. Although U.S. officials were certain that China illuminated the satellite, they offered no firm conclusions about China's motive in doing so. Asked about the incident, General James Cartwright, then-Commander of the U.S. Strategic Command, responded that such a question pertains "to someone actually with intent interfering out there. And we really haven't seen that."[387] The fundamental uncertainty about intent underscores the dual-use nature of the technology: Did Chinese operators attempt to range or image a U.S. reconnaissance satellite, inadvertently interfering with its operation? Or was the interference conducted with intent?

[384] Yang Fumin, "Current Status And Future Plans For The Chinese Satellite Laser Ranging Network," Surveys in Geophysics 22:5-6 (September, 2001) pp.465-471.
[385] Xiong Yaoheng and Feng Hesheng, "Modification of Laser Ranging Equation," *13th International Workshop on Laser Ranging "Toward Millimeter Accuracy,"* (October 2002). Available at: http://cddis.nasa.gov/lw13/docs/papers/atmos_xiong_1m.pdf
[386] Vago Muradian, "China Attempted To Blind U.S. Satellites With Laser," *Defense News*, September 28, 2006: http://www.defensenews.com/story.php?F=2125489, accessed January 24, 2007; "US claims that China has used lasers to attack satellites," *Janes Defense Weekly*, October 16, 2006, http://www.janes.com/aerospace/military/news/jdw/jdw061016_1_n.shtml, accessed January 24, 2007; Andrea Shalal-Esa, "China jamming test sparks U.S. satellite concerns," *Reuters*, October 5, 2006; and Elaine M. Grossman, "Top Commander: Chinese Interference with U.S. Satellites Uncertain," *Inside the Pentagon*, Vol. 22 No. 41, October 12, 2006, http://www.worldpoliticswatch.com/article.aspx?id=267, accessed January 24, 2007.
[387] Elaine Grossman, "Is China Disrupting U.S. Satellites?" *InsideDefense.com*, October 13, 2006.

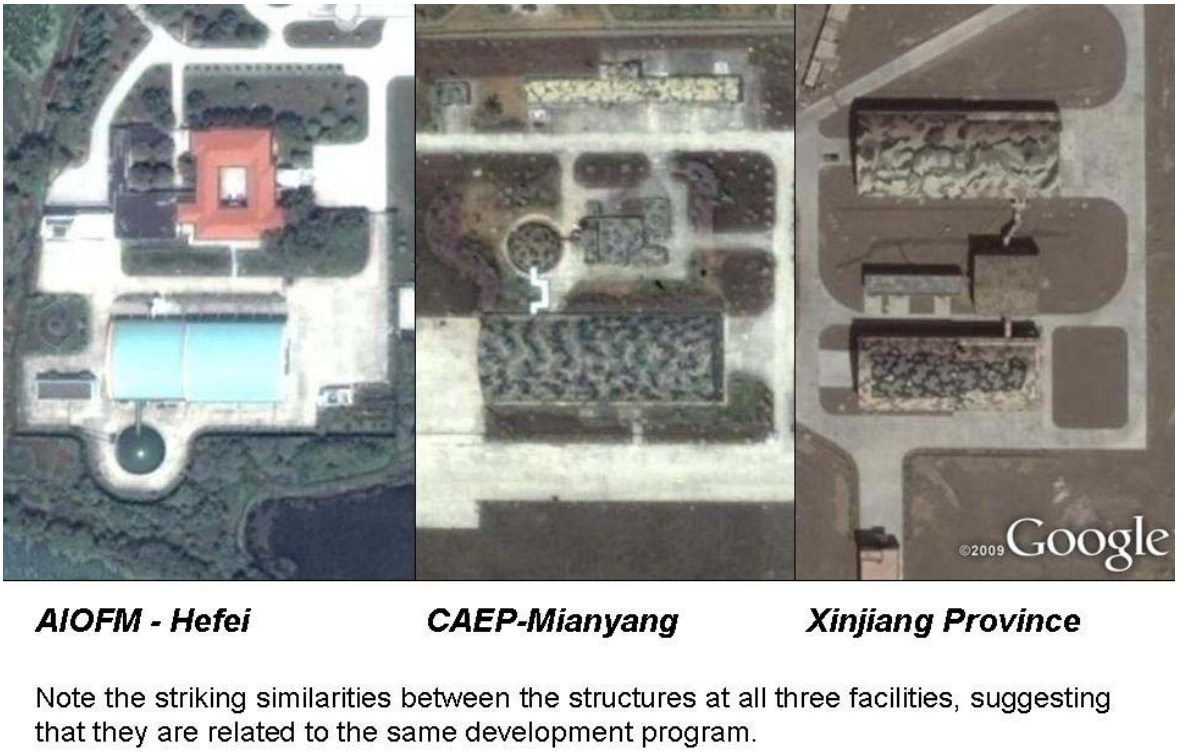

Figure 7: Open Source Speculation Centers on Three Facilities in China
[Source: Sean O'Connor, *China's Other ASAT*, November 3, 2009.[388]]

In 2009, open-source analysis of satellite images found camouflaged buildings with retractable roofs near Miayang and Urumqi that resembled an open facility at the Anhui Institute of Optical and Fine Mechanics, which is known to conduct atmospheric beam experiments. Given the obvious military characteristics of the facilities, as well as the historical work of the China Academy of Engineering Physics on free electron laser (FEL) technology, some analysts have concluded that China may be applying general technologies associated with adaptive optics to a prototype system for tracking, imaging, or damaging U.S. satellites.[389]

388 Available at: http://geimint.blogspot.com/2009/11/chinas-other-asat.html

389 The 863 Project also supported the development of a Free Electron Laser, *Shuguang-1* or *Aurora-1*, at the China Academy of Engineering Physics. Free Electron Lasers have considerable potential as directed energy weapons and Chinese publications on this subject are closely monitored by the United States intelligence community. (Early publications on the FEL at CAEP were translated by the National Air Intelligence Center in the 1990s.)

Case Study 4: China's Acquisition of Strategic Weapons

Joshua H. Pollack

What drives China's development, acquisition, and deployment of nuclear weapons and delivery systems and platforms, including land-based missiles and submarines? It is frequently observed that the PRC is modernizing its strategic forces; in the plain words of the Pentagon's 2009 annual report to Congress on Chinese military power, "China is both qualitatively and quantitatively improving its strategic missile forces."[390] Yet the implications of these trends are less obvious, sparking a debate within the American expert community. This section explores the "who," "what," and "why" of China's strategic weapons acquisition from the start of its nuclear program to the present, with an eye to the future.

The Central Military Commission (CMC), simultaneously an organ of the state and the Chinese Communist Party (CCP), serves as national command authority to the PLA and sets national defense policy and acquisition strategy. Presently chaired by Chinese President and CCP chair Hu Jintao, the CMC exercises its authority through four General Headquarters Departments. The newest of these departments, established in 1998, is the *zong zhuangbei bu,* usually translated as General Armaments Department (GAD). The GAD—described in greater detail below—is responsible for weapons research, development, testing, and acquisition, and controls China's nuclear and missile testing infrastructure. It delivers weapons to the armed services, which in the case of strategic missile systems are the Second Artillery (*dier paobing*) and the PLAN. The operational chain of command proceeds to the armed services from the CMC through the General Staff Department (GSD).[391]

In recent years, the Second Artillery has begun deploying a new generation of solid-fueled mobile nuclear ICBMs. According to DoD, the first DF-31 missiles, with a range of roughly 7,200 km (capable of targeting Russia and India), were fielded in 2006. The first DF-31A missiles, with a range of about 11,200 km (capable of targeting the United States), appeared the following year.[392] The PLAN's first nuclear-powered ballistic-missile submarine of the *Jin* class appeared in commercial satellite imagery in late 2006.[393] The *Jin* submarines are expected to receive JL-2 missiles—sea-based versions of the DF-31—in the near future, if they have not done so already.[394]

These developments follow the appearance of shorter-range solid-fueled ballistic missiles, armed with both conventional and nuclear warheads, during the 1980s and 1990s. The emergence of more advanced missiles of intercontinental range presents a marked technological advance over both the liquid-fueled DF-5A ICBM force that deployed in 1981 and China's lone *Xia* nuclear-powered ballistic missile submarine from the mid-1980s, a very noisy (and therefore detectable) machine that carries 1,000-km-range JL-1 missiles. The *Xia* is not known to have conducted any deterrent patrols.[395] The *Jin* is also considered noisy by world standards and thus is perhaps nothing more than a technological stepping-stone toward more sophisticated submarines.[396]

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[390] Office of the Secretary of Defense, "Annual Report to Congress: Military Power of the People's Republic of China, 2009," p. 24.
[391] Dennis J. Blasko, *The Chinese Army Today: Tradition and Transformation for the 21st Century* (New York: Routledge, 2006), pp. 26-30.
[392] "Annual Report to Congress, 2009," p. 24.
[393] Hans Kristensen, "New Chinese Ballistic Missile Submarine Spotted," *FAS Strategic Security Blog,* July 5, 2007, http://www.fas.org/blog/ssp/2007/07/new_chinese_ballistic_missile.php.
[394] "Annual Report to Congress, 2009," p. 24.
[395] Robert S. Norris and Hans M. Kristensen, "Nuclear Notebook: Chinese nuclear forces, 2008," *Bulletin of the Atomic Scientists,* Vol. 64, No. 3, pp. 42-5.
[396] Office of Naval Intelligence, *The People's Liberation Army Navy: A Modern Navy with Chinese Characteristics,* August 2009, p. 22.

While none of the factual claims above are particularly in dispute, most of the information about Chinese strategic weapons systems has been publicly released by the Pentagon rather than the Chinese. This indirect channel reflects a tradition of opacity in Beijing. The same lack of transparency has contributed to a debate among U.S. experts about the manner in which China's new generation of strategic forces will be operated. Only in hindsight can it be said whether the present moment is one of transformation or essential continuity. However, understanding the question requires an understanding of the general pattern and evolution of Chinese strategic nuclear and missile acquisitions.

The Historic Pattern

There is little controversy about the broad outlines. First, general S&T investment in the PRC has traditionally been centralized and closely linked to defense research and development. (Closely related observations can be made about industrial development, but this area is not the focus of the present discussion.) Nuclear, missile, and strategic naval programs were particularly important national S&T priorities in the early decades after the PRC's founding. It is generally agreed that these programs were viewed in Beijing in part as "seed-beds" for the growth of Chinese S&T as a whole.

Second, China achieved its nuclear weapon milestones relatively quickly by world standards. The country's nuclear ambitions benefitted from a number of factors, including the persistent support of the PRC's senior leadership; a core group of talented, dedicated Chinese personnel trained at first overseas and then at home; Soviet nuclear technology transfers in the 1950s; and the inspiration and example of other countries that had already produced nuclear weapons.

Third, China's approach to missiles and nuclear-powered submarines has been comparatively slow and methodical. In contrast to the nuclear field, Soviet technology transfers in these areas were limited to nonexistent, and the Chinese technical community was not necessarily as strong at the outset. The Second Artillery has nevertheless succeeded at fielding liquid-fueled missiles, followed by solid-fueled missiles, of progressively greater range.[397] The PLAN at first acquired a single nuclear-powered submarine and is now acquiring a second generation of these vessels, usually estimated to be planned at about four or five boats.

Fourth, the technological dimension of China's strategic programs traditionally has outweighed their military dimensions. Despite many qualitative milestones achieved, the PRC has persistently stated a doctrine of no first use of nuclear weapons and refrained from engaging in a quantitative arms race with the world's two largest nuclear powers. Strategic nuclear forces, particularly ICBMs, have been few in number, and warheads are stored separately from missiles.[398]

These decisions can be explained in both ideological and economic terms. First, the Chinese leadership explicitly rejected the "bullying" of the "imperialists" and did not wish to imitate them. Second, since the beginning of the era of economic reform in the late 1970s, supporting economic development has outweighed military spending in Chinese decision-making. (Previously, China would have faced great difficulty funding superpower-scale deployments.) The "continuity" and "transformation" perspectives differ, in essence, over whether these trends persist to the present or have been replaced by new imperatives.

[397] Cruise missiles, hit-to-kill interceptors, and anti-ship ballistic missiles have been discussed in greater depth elsewhere in this report, and are accordingly not emphasized here.
[398] Mark A. Stokes, "China's Nuclear Warhead Storage and Handling System," Project 2049 Institute report, March 12, 2010: http://project2049.net/documents/chinas_nuclear_warhead_storage_and_handling_system.pdf

What follows is a more detailed discussion of the historical development of China's strategic-weapons acquisitions, broken down into three eras: the Mao Zedong era, when China began building and fielding nuclear weapons and liquid-fueled ballistic missiles; the Deng Xiaoping era, starting in the mid-to-late 1970s; and the present era. For convenience, the "present era" will be considered to start with the establishment of GAD in 1998, rather than Deng's formal retirement in 1992 or his death in 1997. The discussion opens with a look at the context of Mao's decision to acquire nuclear weapons, which put an enduring stamp on both acquisitions strategy and operational philosophy.

The Decision for the Bomb

As described earlier in this paper, the Korean War helped to convince the PRC's leaders of the need to acquire advanced military technology, including nuclear weapons. Even before coming to power, Mao Zedong, considering his own experience of (and theories about) protracted guerilla war, had dismissed American nuclear weapons as irrelevant. For Mao, the outcome of armed conflict was determined by "politics." As he explained to an interviewer in 1946, the course of history would not be set by the atomic bomb or any other technology: "The basic question is the consciousness of the people." The United States, Mao was convinced, would never use nuclear weapons again.[399]

Once in power and poised to enter the Korean War against the United States, the rest of the communist leadership was not equally confident. In August 1950—just a year after the first Soviet nuclear test—as the new Chinese government contemplated intervening in Korea, Nie Rongzhen, a senior military figure, felt it necessary to assure one uneasy member of the Central Military Commission of the value of what we would call "extended deterrence": "[The Americans] might use it, but remember that the United States no longer enjoys an atomic monopoly… So they may be less eager to use it nowadays."[400]

The course of the war appears to have contributed to turning Mao himself away from a sanguine view. The severe battlefield losses inflicted upon the China's "volunteers" in Korea by American firepower underscored China's technological inferiority, spurring the Chinese leadership to start the systematic absorption of Soviet scientific publications. But it was the repeated use of nuclear threats by the United States during the Taiwan Strait crisis of 1954-55 that seems to have precipitated Mao's decision to seek nuclear weapons and missiles. The Soviet nuclear umbrella also no longer sufficed; Mao's growing resentment of Khrushchev's high-handedness, combined with his familiarization with the scientific talent that already existed in China, pointed to an independent path.[401] In January 1955, after settling upon the new course, Mao told the Finnish ambassador that China would not succumb to "U.S. atomic blackmail" and "will resolutely strike back" if subjected to nuclear attack.[402]

In the meantime, however, China still relied on conventional weapons alone, and Mao continued to downplay the importance of nuclear weapons in his public remarks. Either the imperialists could not use them, he maintained, because they would destroy the very object of conquest, or their use would bring about a decisive war from which the socialist camp would emerge victorious, recovering from the damage before very long. These ideological attitudes fostered a self-consciously virtuous, anti-imperialist rationale for acquiring the Bomb. "The Guidelines for Developing Nuclear Weapons," a secret document produced by the Central Military Commission in 1958 or 1959, reads in part:

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399 Alice Langley Hsieh, *Communist China's Strategy in the Nuclear Era* (Englewood Cliffs, NJ: Prentice-Hall, 1962), pp. 1-14.

400 Quoted in Sergei N. Goncharov, John W. Lewis, and Xue Litai, *Uncertain Partners: Stalin, Mao, and the Korean War* (Stanford: Stanford University Press, 1993), pp. 164-7.

401 John Wilson Lewis and Xue Litai, *China Builds the Bomb* (Stanford: Stanford University Press, 1988), pp. 35-46.

402 Quoted in Xiaobing Li, "PLA Attacks and Amphibious Operations During the Taiwan Strait Crises of 1954-55 and 1958," in Mark A. Ryan, David M. Finkelstein, and Michael A. McDevitt, eds., *Chinese Warfighting: The PLA Experience Since 1949* (Armonk, NY: M.E. Sharpe, 2003), p. 157.

1. Our country is developing nuclear weapons in order to warn our enemies against making war on us, not in order to use nuclear weapons to attack them….
2. The main reason for us to develop nuclear weapons is to defend peace, save mankind from a nuclear holocaust, and reach agreement on nuclear disarmament and the complete abolition of nuclear weapons.
3. To this end, we have to concentrate our energies on developing nuclear and thermonuclear warheads with high yields and long-range delivery vehicles….
4. In the process of developing nuclear weapons, we should not imitate other countries. Instead, our objective should be to take steps to "catch up with advanced world levels" and to "proceed on all phases simultaneously."
5. In order to achieve success rapidly in developing nuclear weapons, we must concentrate human, material, and financial resources…. Any other projects for our country's reconstruction will have to take second place to the development of nuclear weapons….[403]

One of the implications of this seemingly paradoxical anti-nuclear rationale for nuclear weapons was an explicit minimalism. Thus, in 1957, Premier Zhou Enlai declared that the nuclear program would be "a complete set and form an independent nuclear force; but mainly we should solve the problem of 'having or not.' [T]herefore an excessive force would be unsuitable."[404] Senior military officials looked forward to having "what others have" and a "small but all-inclusive" nuclear force.[405]

Thus, the defining vision of Chinese strategic technology acquisition was the achievement of a *qualitative* national equality. China could not be fully independent either if continually subjected to American nuclear threats or if forced to depend on Soviet protection. The ability to retaliate was described as serving to forestall "bullying," but the fundamental achievement of Chinese nuclear weapons, as expressed in both the "Guidelines" and the announcement of China's first nuclear test, in 1964, was to "break the nuclear monopoly" of the superpowers.[406] Mao himself put it simply: "What the enemy has, we must have."[407]

The PRC would formally announce its first nuclear test on October 16, 1964. Beijing portrayed its possession of nuclear weapons as having essentially no influence on its conduct of international affairs. The 1964 communiqué and the other "detonation statements" that accompanied and justified each of China's early nuclear tests affirmed and reaffirmed a pledge never to resort to the first use of nuclear weapons, foreswore "adventurism"—a thinly veiled criticism of Soviet conduct leading up to the Cuban Missile Crisis—and promised that China would not use nuclear weapons to intimidate others.[408]

The Mao Era: Striving for Equality

The acquisition of nuclear weapons and delivery systems was a high priority for the national leadership in the Mao era, which established close ties between the defense, scientific, and industrial establishments. A series of overlapping and rapidly changing bodies were established in 1955 and 1956, all of which

[403] Quoted in Lewis and Xue, *China Builds the Bomb,* p. 70.
[404] Quoted in Jeffrey G. Lewis, *The Minimum Means of Reprisal: China's Search for Security in the Nuclear Age* (Cambridge: MIT Press, 2007), p. 56.
[405] John Wilson Lewis and Xue Litai, *China's Strategic Seapower: The Politics of Force Modernization in the Nuclear Age* (Stanford: Stanford University Press, 1994), pp. 4, 232-3.
[406] Excerpted in Lewis and Xue, *China Builds the Bomb,* pp. 241-3.
[407] Quoted in Lewis and Xue, *China's Strategic Seapower,* p. 133.
[408] Jonathan D. Pollack, "Chinese Attitudes Towards Nuclear Weapons, 1964-9," *China Quarterly,* (1972), Vol. 50, 244-71.

served in some manner to link military leaders with key scientists and well-connected industrial planners. The central figure in the early years was Marshal Nie, part of a short-lived Three-Member Group appointed by the Politburo in 1955 to oversee the nuclear program. In 1956, Nie assumed leadership of the newly created Aviation Industrial Commission, and then was appointed concurrently to lead the Scientific Planning Commission. Nie was also made vice-premier with responsibility for science policy. In late 1958, at Nie's urging, the Politburo merged the Scientific Planning Commission and the State Technological Commission into a new State Science and Technology Commission, again under Nie's direction. At about the same time, the Aviation Industrial Commission and the Fifth Department of the Ministry of National Defense were merged into a new Defense Science and Technology Commission (DSTC), also headed by Nie, who remained in place until 1967. The DSTC had oversight over the development of nuclear weapons, missiles, and nuclear-powered ballistic missile submarines. Thus, science and technology policy in Mao's China was intimately tied to the development of strategic weapons at the organizational level.[409]

The initial development of nuclear infrastructure depended heavily on Soviet assistance, given in exchange for access to Chinese uranium ore. An initial cooperation agreement was signed in 1956. In 1957, the two sides signed a far-reaching defense cooperation agreement that was to include the transfer of prototype nuclear weapons and missiles. Starting in 1958, Soviet advisers set out to help the Chinese build reactors, a reprocessing plant, and an enrichment facility (the gaseous diffusion plant at Lanzhou), but their cooperation waxed and waned with high-level political developments. Personal relations between Mao and Khrushchev were in decline over conflicting views of strategy against the West. Nuclear cooperation fell to a low point during U.S.-Soviet test ban negotiations in 1959 and ended the next year, leaving the Chinese to complete key facilities on their own.[410]

This development did not deter the Chinese, who renamed the nuclear effort "596," memorializing the Soviet decision to terminate nuclear assistance, conveyed to Beijing in June of 1959.[411] The Chinese went on to complete their infrastructure and design and build nuclear devices in relatively short order. The PRC tested its first nuclear device using highly enriched uranium in October 1964 and its first two-stage thermonuclear device in December 1966. China's first test of a nuclear device using plutonium took place in December 1968.[412]

The transfer of short-range liquid-fueled missiles and diesel-powered submarines from the USSR to China also ended abruptly in 1959.[413] In contrast with nuclear technology, the course of Chinese missile development was seriously hobbled by a lack of experience with important technologies. The ambitions of the early 1960s—to produce a liquid-fueled ICBM capable of reaching the United States—were set aside in favor of more readily achievable goals. The first successful test of a Chinese missile took place in June 1964, but the new missile, called the DF-2, had a range of just 1,050 km. In March 1965, informed by this experience, China's missile designers at the First Academy—a body subject to the oversight of the DSTC—proposed an Eight-Year Plan for the Development of Rocket Technology, which would lead to an ICBM through a progression of four missile types of increasing range (including the DF-2). Each type would have a notional target, culminating in the DF-5, which would be capable of reaching the United States.

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409 Lewis and Xue, *China Builds the Bomb,* pp. 46-59; Lewis and Xue, *China's Strategic Seapower,* pp. 4-10.
410 *Ibid.,* pp. 39-44, 60-5, 112, 188-120.
411 Thomas C. Reed, "The Chinese Nuclear Tests, 1964-1996," *Physics Today* (September 2008), Vol. 61, No. 9, pp. 47-53, at p. 52.
412 Thomas C. Reed, "A Tabulation of Chinese Nuclear Device Tests," September 2008, http://ptonline.aip.org/journals/doc/PHTOAD-ft/vol_61/iss_9/47_1s.shtml.
413 John Wilson Lewis and Hua Di, "China's Ballistic Missile Programs: Technologies, Strategies, Goals," *International Security* (Fall 1992), Vol. 17, No. 2, 5-40, at pp. 7-8, 31-2.

Later that year, in response to reports that the Soviets were building a fractional orbital bombardment system (FOBS)—a missile capable of reaching northern hemisphere targets by way of the South Pole—Premier Zhou ordered the addition of a DF-6 FOBS to the series. Notably, in this case, the Chinese were seeking a capability useful against the United States in order to assert a form of technological equality with the Soviet Union. Another instance of imitation took place in 1970, when, upon learning that the United States was developing missiles with multiple warheads, the First Academy proposed to add the same feature to the DF-6.[414]

Similarly, Marshal Nie proposed to build nuclear-powered ballistic-missile submarines in 1958, within two years of the American decision to do so. As in other cases, there appears to be no record of a specific military rationale for this costly and difficult undertaking. Similarly, the Fifth Academy—the predecessor of the First Academy—has established a Solid Propellant Research Group upon being formed in 1956, apparent in hopes of emulating the Polaris submarine-launched ballistic missile (SLBM) program in the United States.[415]

Despite this basically imitative, technology-centered approach, and an apparent lack of detailed thinking about doctrine or employment of missiles, China's top decision-makers and missile-builders did exhibit strategy-oriented responses to certain external developments. Two examples stand out. First, in 1966—not long after Secretary of Defense McNamara had begun justifying the development of an anti-ballistic missile defense system against future Chinese ICBMs—the First Academy set out to develop a re-entry vehicle with penetration aids for the DF-5, which remained years away.[416] Second, in 1970, shortly after the first successful test of the DF-4, the CMC ordered the redesign of the missile in order to extend its range; fighting with the Soviet Union in the fall of 1969 called for a missile that could reach Moscow from bases in western China.[417]

Still, it was only in the 1970s, under the leadership of Nie's protégé and successor Zhang Aiping, that developers started to grapple seriously with operational realities. As the new missiles were developed, the DSTC recognized that liquid-fueled missiles brought out into the open to prepare for launch might invite pre-emptive attack. The developers struggled to devise viable basing modes and fueling arrangements.[418]

China's attempt to build nuclear-powered submarines with solid-fueled ballistic missiles was even more hobbled by the loss of Soviet support. Chinese engineers had to design and build their own nuclear propulsions systems, a highly complex undertaking that was slowed by the downsizing of the entire project in 1962. Funding was not restored until 1965, the same year that initial studies for the JL-1 solid-fueled SLBM program were initiated. The JL-1 would not be successfully flight-tested until 1981 and did not complete testing until 1988.[419]

As early as 1975, however, it had already become apparent to Zhang that the *Xia* and JL-1 could not support any meaningful operational role; he accordingly decided that the JL-1 would serve mainly as the basis of a new mobile land-based missile, the DF-21. The Second Artillery established its first DF-21 regiment in 1985, three years before the deployment of the original, sea-based version.[420]

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[414] The DF-6 was cancelled in 1973. *Ibid.,* pp. 14-21.
[415] Lewis and Xue, *China's Strategic Seapower,* pp. 4-5, 133-4.
[416] Lewis and Hua, "China's Ballistic Missile Programs," p. 21.
[417] *Ibid.,* p. 17.
[418] *Ibid.,* pp. 22-5.
[419] Lewis and Xue, *China's Strategic Seapower,* 27-33, 139-45, 196-205.
[420] Lewis and Hua, "China's Ballistic Missile Programs," pp. 27-8.

The Deng Era: Civilianization, Exports, and Strategic Modernization

As early as the mid-1970s, with enmity between the United States and China starting to fade, the Chinese leadership began to set a new course, shifting away from strategic weapons development and defense production towards economic development. The defense sector, including the strategic weapons development complex, increasingly came to focus on conventional weapons. This period also marked the beginning of the conversion of defense industry to civil applications.

None of these changes altered the conviction of Chinese leaders that the key to China's future lay in the development of advanced technology. At a 1978 conference, Deng Xiaoping, who had consolidated power after Mao's death in 1976, proclaimed that

> Science and technology are the key to the Four Modernizations… Without modern science and technology it will become impossible to construct modern agriculture, industry, or defense industry. Without the rapid development of science and technology it will become impossible to build the national economy.[421]

Deng's celebrated 16-word edict of January 1982 signaled an intensified program of defense-industrial conversion: "combine the military and civilian, combine peace and war, give priority to military products, and let the civil support the military."[422]

In May 1982, China's top military acquisition, science and technology, and industrial planning organs—the DSTC, the National Defense Industries Office, and the CMC's Research and Equipment Office—were reorganized under the aegis of the Commission of Science, Technology and Industry for National Defense (COSTIND). This new, combined body answered both to the CMC and the State Council, reflecting its role in both military acquisition and industrial planning. As the latest evolution of a frequently reorganized defense-industrial system, COSTIND represented merely the latest attempt to impose a central logic on an increasingly large and diffuse state and party bureaucracy.[423]

In addition to an advisory S&T Committee, the new organization featured a Comprehensive Planning Department and an S&T Department, both implying the ambition to oversee the development and deployment of new technologies from a single body. COSTIND also assumed control of China's missile and nuclear-testing facilities.[424] The designers of strategic systems were well-positioned within COSTIND, but the organization as a whole lacked the influence of its forerunners. Notably, it was headed by a new generation of leaders who lacked the prestige of the military men who had risen to prominence in the Chinese civil war before leading the DSTC. They had not gained their positions through comparable achievements. (Ding Henggao, head of COSTIND until 1996, was the son-in-law of DSTC founder Nie Rongzhen.) COSTIND also had to contend with the State Science and Technology Commission (SSTC), a civilian body re-established in 1977. The SSTC increasingly came to play an agenda-setting role in national technology planning.[425]

If there is a simple moment in which strategic systems were eclipsed as the drivers of national technology development, it would have been March 3, 1986, when Deng gave his blessing to the proposal of an

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[421] Quoted in Evan A. Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age* (Stanford: Stanford University Press, 2003), pp. 111-2.
[422] David Shambaugh, *Modernizing China's Military* (Berkeley: University of California Press, 2004), pp. 250-2.
[423] *Ibid.,* pp. 234-8.
[424] Mark A. Stokes, *China's Strategic Modernization: Implications for the United States* (Carlisle, PA: Strategic Studies Institute, 1999), pp. 215-8.
[425] Feigenbaum, *China's Techno-Warriors,* pp. 118-28.

informal delegation of leading scientists. The "863 Plan," modeled on the earlier "big push" for nuclear weapons and delivery systems, was one of a number of state S&T plans, but had the special advantage of Deng's personal endorsement. 863 fell under the authority of a commission, or "Leading Group," chaired by Song Jian, head of the SSTC as of 1985. Its purpose was to attain world-class high-technology achievements in automation, biotechnology, energy (including nuclear power), information technology, lasers, materials, ocean technology, and space technology (including manned spaceflight).[426]

The developers of strategic systems were forced to adapt. They responded to the new imperative for commercialization by entering the global arms market. During the 1980s, the military established two export corporations, Poly Technologies and New Era. Poly Technologies, founded in 1983, fell under the authority of the GSD; New Era, founded in 1986, fell jointly under the authority of GSD and COSTIND, but primarily the latter. New Era was notable for marketing the M-9 missile—a solid-fueled short-range ballistic missile—and its successors.[427]

Derived from technologies developed for the JL-1/DF-21 program, the M-9 ("M" for "missile," the English word reflecting an orientation to the export market) was exhibited at the First Asian Defense Exhibition in Beijing in November, 1986, where plans for an entire series of M-class theater ballistic missiles (TBMs) were also disclosed. On this occasion, by one account, the M-9 caught the eye of Second Artillery representatives, leading to the production of a domestic version, the DF-15.[428]

During the 1990s, the Second Artillery would deploy hundreds of DF-15 and other Chinese TBMs with conventional warheads opposite Taiwan. This move, which contrasts sharply with the minimalism of nuclear deployments, may reflect the PLA's adaptation to the persistent shortcomings of its air force (the PLAAF) and those of China's military aviation industries.[429] This dynamic would be consistent with the alleged purpose of the development of a medium range conventional TBM, whose 1,700-km range is said to augment, or provide a substitute for, air power in scenarios involving the Nansha (Spratly) Islands in the South China Sea.[430] The PLA is also reported to be in the latter stages of developing a medium range ballistic missile, referred to as the DF-21D, capable of engaging moving targets at sea, such as aircraft carrier battle groups.[431]

Meanwhile, the progress of the JL-1/DF-21 program encouraged China's missile developers to shift to a new generation of delivery systems. In December 1984, COSTIND's Ministry of Space Industry—formerly DSTC's Seventh Ministry of Machine Building—declared that future missile development would emphasize solid propellants, tactical missiles, mobile launchers, and space-launch applications. The next month, the State Council and CMC set out a plan for the next generation of strategic missiles, including the DF-31 ICBM and its sea-based variant, the JL-2. In 1986, plans were announced for a three-stage DF-41 ICBM, since set aside in favor of the DF-31A.[432]

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[426] *Ibid.,* pp.,141-71, 193.
[427] John W. Lewis, Hua Di, and Xue Litai, "Beijing's Defense Establishment: Solving the Arms-Export Enigma," *International Security* (Spring 1991), Vol. 15, No. 1, pp. 87-109, at pp. 92-6, 107.
[428] Lewis and Hua, "China's Ballistic Missile Programs," pp. 34-6.
[429] On these subjects, see: Kenneth W. Allen, Glenn Krumel, and Jonathan D. Pollack, *China's Air Force Enters the 21st Century* (Santa Monica: RAND, 1995).
[430] Lewis and Hua, "China's Ballistic Missile Programs," pp. 30-1.
[431] See *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2010*, Office of the Secretary of Defense: http://www.defense.gov/pubs/pdfs/2010_CMPR_Final.pdf, p. 31; see also Andrew S. Erickson and David D. Yang, "On the Verge of a Game-Changer," *Proceedings Magazine*, May 2009; and Mark Stokes and Ian Easton, "Aerospace Trends in the Asia-Pacific Region: Implications for Stability in the Taiwan Strait and Beyond," Project 2049 Occasional Paper, May 27, 2010.
[432] *Ibid.,* pp. 28-30.

The warheads deployed on all of China's solid-fueled strategic nuclear missiles appear to be essentially the same.[433] After 46 nuclear tests, China signed the Comprehensive Test Ban Treaty in 1996. Stockpile development was already considered complete in 1992, after 38 tests; the remainder are described as related to engineering, safety, and reliability.[434]

The Present Era: Maturation

On April 3, 1998, COSTIND was abolished in favor of a new, fourth department of the PLA High Command, the GAD. (A new, purely civilian COSTIND was also established, usually called "State COSTIND" or SASTIND to distinguish it from its far more significant predecessor.) COSTIND's last director, Lieutenant General Cao Gangchuan, became the first chief of GAD, taking with him the old organization's most important assets, apparently including all space launch and missile test facilities and the New Era Corporation. GAD also absorbed elements of the GSD and General Logistics Department (GLD) related to equipment.

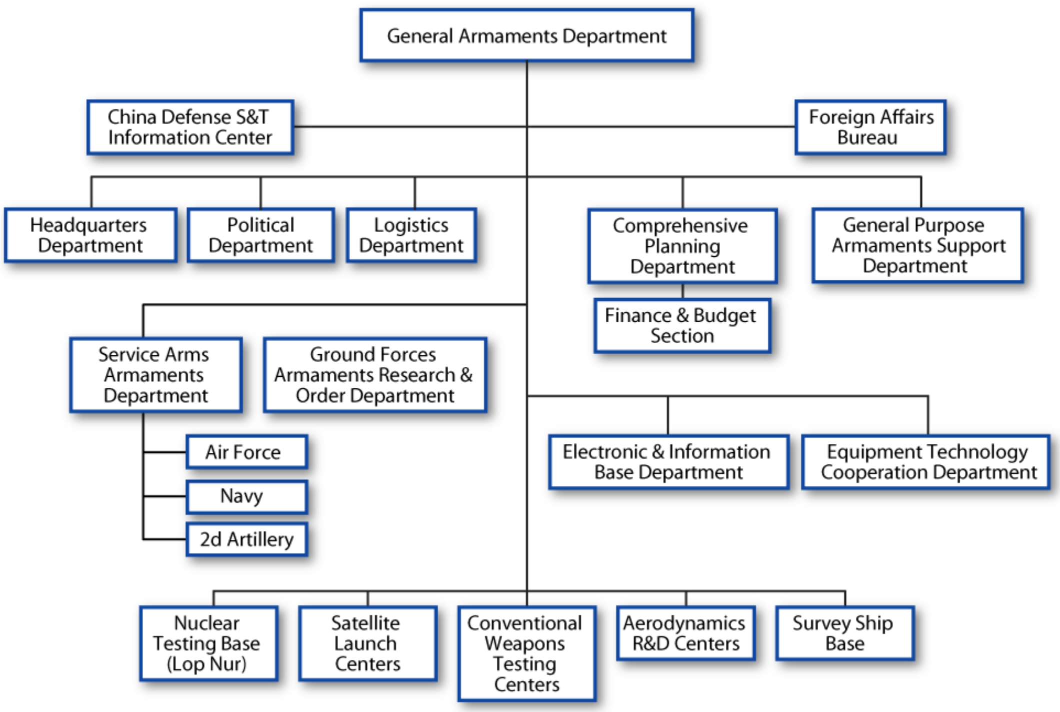

Figure 8. Organization of the General Armaments Department. Adapted from David Shambaugh, *Modernizing China's Military* (Berkeley: University of California Press, 2004), p. 145.

In effect, GAD now stands as a consolidated middleman between arms-makers and the service arms of the PLA, who are represented within GAD liaison bureaus. An organizational chart appears above as Figure 8.[435] However, service-level entities have gradually assumed some of the responsibilities formerly carried out by GAD. For example, the Second Artillery Equipment Research Academy was formed in December 2003 to better leverage available technologies for the purpose of force modernization as well as address stovepiped research entities. Among its tasks are feasibility studies and concept development for new missile systems and oversight of industrial R&D and testing. Since the first competitive tender

[433] *Ibid.,* p. 30.
[434] Reed, "A Tabulation of Chinese Nuclear Device Tests."
[435] Harlan Jencks, "The General Armament Department," in James Mulvenon and Andrew N.D. Yang, eds., *The People's Liberation Army as Organization: Reference Volume v1.0*, (Santa Monica: RAND, 2000), pp. 273-308; Shambaugh, *Modernizing China's Military,* pp. 143-46, 233-41, 283-4.

in 2002, the Academy plays a role in evaluating bids for industrial R&D contracts. The Academy also oversees at least five research institutes. Program management of larger, more complex systems is handled at the Academy level, while sub-systems are managed at the institute level.[436] The Second Artillery also maintains a system of liaison offices within defense industrial academies, research institutes, and factories as a means of monitoring R&D and production contracts and ensure quality control.[437]

As a supplier of modern arms, GAD has not confined itself to Chinese industry; it has also emerged as a large-scale buyer of foreign weapons systems, most prominently from Russia.[438] This relationship appears to have deepened considerably after the accidental bombing of the Chinese embassy in Belgrade by the U.S. Air Force in 1999.[439] Arms sales from Russia, which actually extend back to 1992, include fighter-bomber, transport, and early-warning aircraft; helicopters; advanced air-defense missiles; main battle tanks; diesel submarines; and destroyers with advanced anti-ship missiles.[440]

This shift to foreign sourcing does not mean that military R&D no longer plays a role in China's technological aspirations. GAD holds a seat on the Program Committee for the 126 Program, whose name recalls a January 26, 2000, conference announcing the program. President Jiang Zemin, as CMC Chairman, approved a series major military technology projects, echoing the more civilian or dual-purpose 863 Plan of the 1980s and 1990s. Its six areas are aerospace technology, electronic information technology, strategic defense technology, deep-strike counterattack technology, laser-optic technology, and non-conventional and conventional materials technology.[441] The emphasis on aerospace, information technology, and precision strike may reflect a response to the Kosovo conflict in 1999, but perhaps even more, the enduring impression made by the Persian Gulf War in 1991.[442] Just two of six areas—strategic defense technology and deep-strike counterattack technology—fit squarely in the "strategic" category, and neither involves nuclear weapons applications.

In this new environment, with its emphasis on high-technology conventional weapons, the role and relevance of the Second Artillery and the strategic arms of the PLAN appear greatly diminished. With the possible exception of future ballistic-missile submarines, these strategic forces now seem to be harvesting the fruits of the research and development of the Mao and Deng eras, with no new major systems currently in sight. Ongoing Second Artillery modernization efforts are described in terms of updating its equipment, training, information technology, and logistical systems.[443]

Officially, the operational role of strategic forces is now bifurcated, reflecting the divide between the Second Artillery's nuclear and conventional missile forces:

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[436] For general background on the Academy, see "How Did the Second Artillery Corps Create More than 6,000 S&T Results?" *PLA Daily*, February 11, 2009: http://news.xinhuanet.com/mil/2009-02/11/content_10798697.htm

[437] See "Report on Second Artillery Representative Offices" [来自二炮军代室的报告], *PLA Daily*, April 25, 2001: http://health.eastday.com/epublish/gb/paper200/1/class020000007/hwz274633.htm

[438] *Ibid.,* p. 284.

[439] Kurt M. Campbell and Richard Weitz, "The Chinese Embassy Bombing: Evidence of Crisis Management?" in Michael D. Swaine et al., eds., *Managing Sino-American Crises: Case Studies and Analysis* (Washington, DC: Carnegie Endowment for International Peace, 2006) pp. 327-49, at pp. 333-5.

[440] Richard Weitz, "Why Russia and China Have Not Formed an Anti-American Alliance," *Naval War College Review* (Autumn 2003), Vol. 56, No. 4, pp. 39-61, at pp. 43-4.

[441] Jencks, "The General Armament Department," p. 281.

[442] Allen, Krumel, and Pollack, *China's Air Force Enters the 21st Century, p*p. 31-34.

[443] *China's National Defense in 2008* (Beijing: Information Office of the State Council of the People's Republic of China, January 2009), pp. 30-31.

> The Second Artillery Force sticks to China's policy of no first use of nuclear weapons, implements a self-defensive nuclear strategy, strictly follows the orders of the CMC, and takes it as its fundamental mission the protection of China from any nuclear attack. In peacetime the nuclear missile weapons of the Second Artillery Force are not aimed at any country. But if China comes under a nuclear threat, the nuclear missile force of the Second Artillery Force will go into a state of alert, and get ready for a nuclear counterattack to deter the enemy from using nuclear weapons against China. If China comes under a nuclear attack, the nuclear missile force of the Second Artillery Force will use nuclear missiles to launch a resolute counterattack against the enemy either independently or together with the nuclear forces of other services. The conventional missile force of the Second Artillery Force is charged mainly with the task of conducting medium- and long-range precision strikes against key strategic and operational targets of the enemy.[444]

In the view of some American analysts, these official explanations and assurances do not reflect a new ferment in the doctrinal world. Some read into authoritative Chinese discussions of nuclear counterattack campaigns the possibility of what one analyst calls "preemptive counterattacks," but this conclusion involves extrapolating past conventional warfare practices into future nuclear doctrine.[445] Other analysts suggest that the growth of conventional and theater nuclear forces is driving a debate within China about the enduring merits of a no-first-use policy, and identify scenarios that might trigger a departure.[446] Another view within the analytic community is that the emerging generation of Chinese nuclear forces, even with modern missiles and equipment, do not constitute the basis of a doctrinal departure in themselves. These forces will probably be operated on low alert in ordinary circumstances, separately from their warheads, as the previous generation of weapons have been.[447]

A concern broadly shared among analysts, however, is the possibility of miscalculation, potentially related to the deployment of conventional missiles in a direct-ascent anti-satellite or anti-ship capacity, or accidents at sea involving the Chinese ballistic-missile submarine force. China's command-and-control systems have yet to catch up with its weapons systems, particularly at sea. The interactions between U.S. and Chinese forces, new and old, therefore represent the greatest unknowns.[448]

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444 *Ibid.,* p. 29.

445 Larry M. Wortzel, *China's Nuclear Forces: Operations, Training, Doctrine, Command, Control, and Campaign Planning* (Carlisle, PA; Strategic Studies Institute, 2007), pp. 14-9.

446 Michael S. Chase, Andrew Erickson, and Christopher Yeaw, "Chinese Theater and Strategic Missile Force Modernization and its Implications for the United States," *Journal of Strategic Studies* (February 2009), Vol. 32, No. 1, pp. 67-114, at pp. 94-8.

447 Jeffrey G. Lewis, "Chinese Nuclear Posture and Force Modernization," *Nonproliferation Review* (July 2009), Vol. 16, No. 2, 197-209, at pp. 202, 204-5.

448 Chase, Erickson, and Yeaw, "Chinese Theater and Strategic Missile Force Modernization and its Implications for the United States," pp. 87; Lewis, "Chinese Nuclear Posture and Force Modernization," pp. 205-6; Joshua Pollack, "Emerging Strategic Dilemmas in U.S.-Chinese Relations," *Bulletin of the Atomic Scientists* (July/August 2009), Vol. 65, No. 4, pp. 53-63.

APPENDIX – SECTION 1: OVERT ACQUISITION OF FOREIGN WEAPONS AND TECHNOLOGY

General Literature

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