ATTACKING THE EMPTY: PEOPLE'S REPUBLIC OF CHINA FOREIGN-MISSILE TECHNOLOGY ACQUISITION AND IMPLICATIONS ON FUTURE TECHNOLOGY BANS

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14. ABSTRACT
The People?s Republic of China (PRC) has improved its surface-to-surface missile capabilities over the last decade by acquiring foreign missile technology. Despite bans on the importation of missile-related items, the People?s Liberation Army (PLA) has integrated foreign technology into existing missile systems. The PLA has gained a military advantage over Taiwan and the United States due to a lack of missile defense systems to counter missile attacks. In the coming decade, the application of precision will further enhance missile capabilities. By understanding the impact of technology integration, the central question is whether a future ban on precision technology will affect the PLA?s missile capabilities. By analyzing the PLA?s advanced missile programs, an assessment is made on what these programs will be used for and what precision-related items these programs require. Second, an analysis is made on what precision subsystems these programs lack and will likely be sought. Third, an assessment is made regarding the PRC?s missile capabilities against current and future missile defenses developed by the United States and Taiwan. In conclusion, a missile gap exists that favors the PRC; however, precision technology is required to maintain this advantage and a future ban on certain technology would close this gap.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

ATTACKING THE EMPTY: PEOPLE'S REPUBLIC OF CHINGA FOREIGN-MISSILE TECHNOLOGY ACQUISITION AND IMPLICATIONS ON FUTURE TECHNOLOGY BANS, by MAJ Charles T. Duray, 60 pages.

The People's Republic of China (PRC) has improved its surface-to-surface missile capabilities over the last decade by acquiring foreign missile technology. Despite bans on the importation of missile-related items, the People's Liberation Army (PLA) has integrated foreign technology into existing missile systems. The PLA has gained a military advantage over Taiwan and the United States due to a lack of missile defense systems to counter missile attacks. In the coming decade, the application of precision will further enhance missile capabilities. By understanding the impact of technology integration, the central question is whether a future ban on precision technology will affect the PLA's missile capabilities. By analyzing the PLA's advanced missile programs, an assessment is made on what these programs will be used for and what precision-related items these programs require. Second, an analysis is made on what precision subsystems these programs lack and will likely be sought. Third, an assessment is made regarding the PRC's missile capabilities against current and future missile defenses developed by the United States and Taiwan. In conclusion, a missile gap exists that favors the PRC; however, precision technology is required to maintain this advantage and a future ban on certain technology would close this gap.

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CHAPTER 1

INTRODUCTION

Few countries have achieved more dramatic results in missile development over the last decade than the Peoples Republic of China (PRC). Through aggressive open and covert economic means, the Peoples Liberation Army (PLA) has successfully sought, acquired, and integrated foreign technology into the development of ballistic and land-attack cruise missiles. In so doing, China has established itself as a regional power with a dominating military force in Asia, and asserted itself as a growing nuclear threat to the continental United States. As the PRC seeks to reduce the military effectiveness of our armed forces, the political clamor within the United States to restrict advanced technologies increases. By examining the current and future capabilities of Chinese missile development, this study assesses the acquistion of precision technologies over the last decade. Provided this assessment of the PRC's missile program, will a ban on missile technology be effective over the next ten years?

Missile activities in the last decade underscore the PRC's striking progress in land- and sea-based attack systems, as well as the effects such systems can have on a region. In July 1995, China announced its intention to launch tactical ballistic missiles (TBMs) in the Taiwan Strait, and then actively employed and fired indigenously-produced TBMs just 60 kilometers north of Taiwan during military exercises in the South China Sea, causing the Taiwan stock market to drop 4.2 percent as well as diverting commercial air and shipping traffic away from the area (New Taiwan, 1-2). Subsequent firings in 1996 destabilized the region as DF-15 missiles landed within 51 kilometers of Kaoshiung, the world's third largest container port (New Taiwan, 1-2). The firings, in many ways a response to Taiwanese political preference for independence over reunification, were classic examples of showing strength by attacking the empty--the Sun Tzu principle of demonstrating the capability to strike the enemy where he is unprepared, thus inducing in the enemy an unwillingness to stand and fight.

PRC missile development has been not only designed to target Taiwan, but also to strike at targets within the United States. With the reinvigoration of military and security ties between Taiwan and the United States, the PLA sought to develop and acquire missile technologies in order to overcome future missile defense systems. In 1999, the PRC successfully tested the road-mobile Dong Feng-31 (DF-31) TBM and in 2001, tested the submarine-launched Julang-2 (JL-2) ICBM. As late as July 2002, the PRC has tested missiles that employ decoy, or dummy, warheads, which are designed to confuse and defeat missile defenses. The CIA estimates that by 2015, the PRC's ballistic missile force "will increase several-fold" (CIA *Questions for the Record* 2002).

Before discussing specific technologies, a review of the PRC's missile programs must be addressed. China has undertaken a two-pronged approach by developing both ballistic and cruise missiles. Ballistic missiles are those systems that rely on a fueled trajectory to achieve an apex, and then use ballistic force to deliver their payloads. Joint Publication 1-02 defines a ballistic missile as "any missile which does not rely upon aerodynamic surfaces to produce lift and consequently follows a ballistic trajectory when thrust is terminated" (Joint Pub 1-02 2001, 46). On the other hand, cruise missiles are entirely dependent on their fuel and navigational systems to deliver and guide their payloads, with precision, to the target. Unlike ballistic missiles, cruise missiles follow a flight path that "depends on the dynamic reaction of air for lift and upon propulsion forces to balance drag" (JP 1-02 2001, 111). The focus of this study is limited to those ballistic and cruise missile systems that could significantly negate current and future missile defense systems of the United States and Taiwan.

Precision is a critical requirement for missiles. This is a major consideration in assessing the PRC's missile capabilities, because the more precisely a payload can be delivered to a target, the better the missile system and its functional components. Precision is measured by the circular error probable (CEP). CEP is the measurement that indicates precision and potential damage to the target. As defined in Joint Publication 1-02, CEP is:

> an indicator of the delivery accuracy of a weapon system, used as a factor in determining probable damage to a target. It is the radius of a circle within which half of a missile's projectiles are expected to fall. (JP 1-02 2001, 70)

Those systems that can deliver larger, more powerful payloads within an acceptable CEP that allows for the destruction of the intended target, are the most threatening.

The PLA has taken interest in precision munitions over the last decade, primarily in the development of land-attack cruise missiles (LACMs). Because of their guidance and precision characteristics, a CIA assessment indicated that PRC cruise missiles were a "potential counter" to U.S. missile defenses (CIA *Questions for the Record* 2002). PLA military strategists have begun to emphasize the concept of precision, stating that "Precision-kill weapons can hit a target precisely, reducing collateral casualties . . . so that inconspicous combat actions can achieve extremely notable strategic results" (Liang and Xiangsui 2002, 19). CEP can also affect nuclear, biological, and chemical (NBC) payloads, since smaller, less-lethal effects can be produced against specific targets without collateral damage to noncombatants that is normally expected from NBC payloads.

The analysis of current and future PRC missile capabilities leads to a second concern--those foreign technologies that the PRC can use to leverage or contribute to its missile development. Not only are precision systems important, but technologies that are dual-use--have a civilian as well as military capability--will be addressed as well as future, advanced applications that are of military importance to any missile development program. The discussion of what components were imported or reverse-engineered will be limited to the actual missile systems in this study.

An in-depth analysis of how technologies were transferred into the hands of the PLA is beyond the scope of this study. However, the importation and acquiring of technology by Chinese resources is an embedded part of the assessment. Acquisition tactics such as solicitation, spying, exploitation of officials, covert collection, theft of technologies and information, and agent recruitment will not be explained in detail.

The PRC is a major weapons-trading nation, and although it exported generally less updated missile technology than what it imported, the PRC maintains weapons-trading relationships with other countries in order to acquire the missile technologies that it needs. Only recently did the PRC officially disclose its own version of an export control list of missile technology. The PRC did this in contrast to agreeing in principle to the 1987 Missile Technology Control Regime’s (MTCR) list, which is a list developed and approved by 32 nations that voluntarily limit export licences on missile-related items. Seemingly, publishing a separate list allows the PRC to retain the right to license and export certain technologies to partners such as Iran and Pakistan while maintaining a political posture against such activities (CNS, *Chinese Export Controls and Jiang Zemin's Visit to the United States* 2002).

The PRC did not readily accept the MTCR specifics on the exportation of technology, as did nations such as France, Germany, Japan, Russia, and the United States. This, in part, was due to the PRC's view of missile defense systems, such as the developing U.S. Theater High Altitude Air Defense (THAAD) system, as "a double standard applied to certain MCTR members" (Yuan 2002, 2). The lack of resolve sheds light on the PRC's strategic intentions to develop missile capabilities to overcome real and planned U.S. missile defenses.

Although the purpose of this study is not to discuss Chinese strategic ways in detail, the relationship of current and future capabilities to accomplish certain regional objectives will be referred to. The reunification of Taiwan is a national objective for the PRC, and the PLA develops and deploys ballistic missiles for targets in Taiwan in order to support a military solution to reunification if required. Understanding future concepts espoused by personnel associated with the PLA provides insights into technologies the PRC may seek.

The third concern that will be addressed is whether China has achieved or could achieve mastery of aerospace through missile attacks. This is an important consideration that is relevant to understanding the significance of the PRC's missile programs, as well as identifying possible, future technologies that should be banned. Because joint doctrine for countering air and missile threats addresses the degree of dominance to "limit an enemy's ability to conduct air and missile attacks," an assumption will be made that the definitions used in a traditional air-breathing threat (aircraft) campaign--air parity, air superiority, and air supremacy--also define the degree to which China's missile capability can act against an adversary's missile defense systems (Joint Pub 3-01 2001, v).

In order to provide a focused understanding of ballistic and cruise missile contributions to air parity, air superiority, and air supremacy, the term "missile" will be used instead of "air." The subsitution of terms not only avoids confusion as to terminology, but allows for further resolution on the PRC's missile capabilities against friendly missile defense systems, particularly with regard to U.S. development of theater and national missile defense capabilities.

Hence, missile parity is defined as the functional equivalency between enemy missile threats and friendly air forces and air defense systems in strength and capability to attack or prevent attack concurrently. Under this condition, where neither side has gained superiority, missile attacks could affect friendly ground forces but not severely disrupt operations.

Missile superiority is defined as the degree of dominance of enemy missile forces which permits the attacking enemy missile force to strike friendly ground force targets at a given time and place without interference from friendly air forces or air defense systems (JP 1-02 2001, 22). Under this condition, the enemy can target operational and strategic centers of gravity with success.

Finally, missile supremacy is the degree of dominance wherein the friendly air force and air defense systems are incapable of effective interference (JP 1-02 2001, 22). Despite some limitations within these definitions, assessments in the form of missile versus missile comparisons may become an unavoidable consideration for military planners in the future missile battle environment.

Although limited in nature and classification, a comparison of the PRC's capability with U.S. and Taiwanese missile defense systems, both present and in the future, is necessary. A comparison of missile systems against missile defenses will highlight the precision technologies critical to the PLA sustaining or achieving a higher degree of dominance during a missile campaign.

Finally, this study does not investigate the feasibility of banning or enforcing controls on missile technologies. Rather, this study draws a conclusion regarding the impact on denying the PRC certain identified technologies and advanced applications for the PLA's missile programs. By limiting the scope to technologies that affect ballistic missiles and land-attack cruise missiles, a targeted analysis can be referenced to develop future strategies and courses of action for the prevention, denial, and disruption of technological improvements in the Chinese missile program.

CHAPTER 2

LITERATURE AND STRATEGIC REVIEW

This study has an excellent amount of information and sources to reference from. The increasing public and private interest of missiles and their effects can be attributed to many factors over the last ten years. The Internet is a major influence in the spreading of ideas by scientists, historians, and social organizations that are concerned about missile proliferation and the PRC's intent to use them against an adversary such as Taiwan. Magazine and newspaper journalists have their articles readily available on the web, while government reports and reference materials are consolidated and easily resourced.

Books written about the PRC's missile programs and intentions can be divided as pre-9/11 and post-9/11 material. Prior the 9/11 attack, studies generally predicted that, although the PRC's missile threat was growing, the PLA was not capable of developing missile technology to the point of decisively defeating U.S. missile defenses, or threatening the continental United States for that matter, by 2010 or 2015. The PRC was viewed as a regional threat to Taiwanese designs for independence, as the 1995 and 1996 missile firings in the Straits attested to that intention. A missile defense shield was not a priority to the Clinton Administration, because Iraq and North Korea were regarded as the regional threats that faced the United States with weapons of mass destruction (WMD). Due to their limited resources, these rogue states were thought to have lacked the capability of harming neighboring states as long as they remained isolated.

On the other hand, significant post-9/11 material indicates that the PRC is a potential adversary to the United States in the contemporary operating environment (COE). Both public- and private-sector organizations link the threat of WMD across the world to the PRC's exportation of missile technologies during the previous decade. The PRC is recognized as a major part of the problem, primarily because of its role as an exporter of WMD missile delivery systems. Chinese SSMs were reported to have been fired by Iraqi missile forces at Kuwait during Operation Iraqi Freedom. The PLA's ability to threaten the continental United States is now the impetus for the Bush Administration to make missile defense a priority, and the threat of war between India and Pakistan has generated significant interest by institutes to understand how nations such as Pakistan acquired and developed ballistic missile technology (much of which came from the PRC), as well as how future ballistic and cruise missiles will be employed. The renewed interest in WMD capabilities has inclined nonproliferation organizations to study and outline export controls on dual-use technologies, while independent organizations devote more effort to reporting on missile sales by third parties, rather than just the traditional airframe or ground arms sales by nations and legitimate businesses.

Unrestricted Warfare is one of the few literary works that did not fit the pre-9/11 mold. Written by two Chinese Colonels, Qiao Liang and Wang Xiangsui, and published by the PLA in 1999, *Unrestricted Warfare* introduces and advocates many forms of warfare to include trade, financial, international law, computer network, drug and smuggling, cultural, psychological, and even ecological. The authors argue that technology has changed war by extending the battlespace (from the inner heart of a human to the far reaches of space) to such a degree that traditional combat is obsolete. The book is controversial, as the authors alluded to the 9/11 attack three years in advance:

> Whether it be the intrusions of hackers, a major explosion at the World Trade Center, or a bombing attack by bin Laden, all of these greatly exceed the

> frequency band widths understood by the American military. (Liang and Xiangsui 2002, viii)

Unrestricted Warfare does more than provide a vision for terrorism. The book implicitly justifies the use of smuggling technologies and explicitly advocates precision weapons as sanctioned warfare in relation to the "side-principal rule." The side-principal rule is an ancient form of Chinese sword fighting in which the fighter seeks to attack his opponent not at the point of his sword nor his guarding stance, but where his opponent is weakest. Cruise missiles serve this purpose, as an adversary's communications networks, rear assets, and undefendable areas can be attacked far from the geometry of a battlefield.

The authors have developed the future battlefield calculus as one of "combinations," as the method of operation in which success in war could quite possibly mean "combining the military and non-military which is more specifically combining stealth aircraft and cruise missiles with network killers, combining nuclear deterrence, financial wars and terrorist attacks" (Liang and Xiangsui 2002, 120). In its essence, *Unrestricted Warfare* sanctions the future use of accurate ballistic and cruise missiles to achieve military ends against the United States, as long as the PRC does not attempt to engage in an expensive, conventional arms race with capitalism.

To further understand Chinese military thought and the changes that affect it, *The Art of War,* written by Sun Tzu, provides excellent insight into the Eastern philosophy of winning without fighting, or "to avoid the full and attack the empty" (Sun Tzu 1988, 112). Understanding the PRC's strategic intentions to develop and deploy missiles is related to the traditional Chinese conduct of war on the various kinds of grounds promulgated by Sun Tzu. Prior to the introduction of missile technology, the United

States could be considered “bad ground,” as it is difficult to travel to and attack; the Pacific Ocean as “trafficked ground,” as all nations can come and go as they wish under relatively safe conditions; and Taiwan viewed by the PLA as a “ground of contention”, as it would be advantageous for the PRC or the United States to maintain its sphere of control over it (Sun Tzu 1988, 148-149).

Ballistic and cruise missile technologies have the potential to change this paradigm. Under the dictates of “Master Sun,” Taiwan would remain a ground of contention, while cruise missiles could affect forces at staging bases in the Pacific Ocean or enroute to Taiwan--thus turning trafficked ground into “intersecting ground” in which the control and free access by the United States is very much in doubt (148). Finally, ballistic missiles could threaten not only the ground of contention and intersecting ground, but also the United States, turning the continental United States into “heavy ground” by which ballistic missiles could “enter deeply into others’ land” (149). The relationship of ancient forms of Chinese warfare to the employment of missile systems should not be lost. The Dong Feng and Julang series missiles are named after natural phenomena. Translated, the Dong Feng series missiles literally mean “East Wind,” while the sea-launched land-attack series missiles are aptly named Julang, or “Great Wave.”

The ground of contention that is Taiwan is a powerfully emotional force for soldiers in the PLA, as many scholars, political scientists, and historians agree. Andrew Scobell’s paper, *Show of Force: The PLA and the 1995-1996 Taiwan Strait Crisis*, articulates that, although the PLA was not up to the challenge of invading the island of Taiwan, the use of “coercive diplomacy” during the crisis revealed that the PLA is “actively preparing to take Taiwan by military means if need be” (Scobell 1999, 15). He cites many senior PLA officers as not only prepared to crush Taiwanese independence, but also prepared to act against a United States that is seen as the primary threat to the reunification of China. Despite limitations in aircraft, naval capabilities, and amphibious practices, Scobell concludes that the PLA has a "clear superiority" of missile technology over Taiwan that could be used to offset Taiwan's advantage in aircraft while terrorizing the island's populace (Scobell, 16).

The PRC's 2000 white paper on national defense reflects this aspiration to reunite Taiwan even under "profound changes in the world's military sphere, and prepare for defensive operations under modern, especially high-tech, conditions" (China's National Defense 2000, 2). The paper clearly states that the PRC's "fundamental aim in developing science, technology, and industry for national defense is to satisfy the basic demands . . . and raise the level of national defense modernization" (China's National Defense 2000, 5). In addition, the PRC openly criticizes the United States' development of national missile defense (NMD) and theater missile defense (TMD), as well as joint U.S.-Japan and U.S.-Taiwan missile defense partnerships.

Unlike the 2000 white paper, the 2002 national defense paper notes accomplishments in the organization of PLA research institutes as well as a more in-depth recognition of ballistic missile treaties and the PRC's desire to align itself against missile proliferation. Post-9/11 attitudes are reflected in an openness to engage in diplomatic areas, to include military partnerships and exchanges, and to resolve issues. However, the paper notes the PRC's stalwart stance against missile defense development and joint-U.S. partnerships, particularly with Taiwan. This suggests that the PLA's 2nd

Artillery Corps and its complement of missile units would play a critical role in military action in support of the single China policy.

The threat of missile attack by the PRC is a major concern for both public and private sectors in Taiwan. Websites such as *New Taiwan* provide articles relevant to the PRC's missile threats through chronological data, independent journals, and up-to-date newspaper articles from sources such as the *Taipei Times* and CNN, as well as organizations in favor of Taiwanese independence.

The discussion of missile technology and the various components that provide for the testing, development, production, and employment is made easier with the *Missile Technology Control Regime Handbook*, which is a useful tool to define the missile technologies that the PRC possesses or requires. The MTCR is a voluntary organization made up of thirty-two countries whose government representatives coordinate their respective export controls on missile technology or technologies that have dual-use capabilities. The representatives meet annually to update missile export controls on ballistic missiles and unmanned aerial vehicles (UAVs, which the MTCR considers to include cruise missiles by the MTCR) that are "capable of delivering at least 500 kilograms payload to a range of at least 300 kilometers" (BIS 2002). The MTCR Annex allows those volunteer nations to define certain technologies as a group in order to avoid ambiguous and different definitions that circumvent the export control list. The MTCR Annex is divided into two categories. Category I includes complete rocket (ballistic missiles are defined here) and UAVs. Businesses or parties that seek to export such should be denied licenses, or be "subject to a strong presumption of denial" (MTCR Annex 1998, i). Category II items are "subject to a case-by-case basis review," and include propulsion, launch, ground support equipment, and other subsystems related to missile technology (MTCR, ii). The MTCR Annex is further divided into twenty subcategories that include systems, such as

rockets	complete subsystems
propulsion components and equipment	propellants
propellant production	composite production
pyrolytic technology	structural materials
navigation equipment	flight controls
avionics	launch support
computers	analog-to-digital converters (ADCs)
test equipment	modeling and design software
stealth	nuclear effects protection
other systems	other complete subsystems.

Although the MTCR focuses on the licensing and exportation of missile technologies, the Annex provides insight into certain precision capabilities that the PRC may desire to seek in order to improve missile accuracy and greater range. Among the twenty subcategories that are important to precision are:

propulsion components and equipment	propellants
composite production	navigation equipment
flight controls	avionics
launch support	computers
analog-to-digital converters (ADCs)	test equipment
modeling and design software	

These subcategories are detailed in chapters 3 and 4.

An international conference in the Hague in November 2002 introduced a draft International Code of Conduct Against Ballistic Missile Proliferation, with ninety-three countries--not including the PRC--subscribing. This new code will replace the MTCR, with a meeting planned in the Spring of 2003 to begin working out the details to reduce the amount of development, testing, and spread of ballistic missiles.

A study, written by Phillip C. Saunders, *Preliminary Analysis of Chinese Missile Technology Export Control List*, provides insights on what missile technologies the PLA will export to other countries. More importantly, the omission of certain items on the PRC's 2002 export control list suggests what the PRC needs to acquire to improve its own missile programs.

Because the PRC is not a full partner in the MCTR, a separate Chinese export control list was published in August 2002 to clarify the PRC's position on certain missile technologies. Saunders identifies discrepancies in the PRC's export control list from those in the MTCR Annex. In terms of subcategories that are related to precision and missile accuracy, he notes omissions or differences in propulsion components and equipment, navigation, avionics, launch support, and ADCs. Saunders notes the possible reason why high-acceleration gyros and accelerometers were omitted, stating: "It is possible that these items were omitted to facilitate potential Chinese cooperation with Russia in developing maneuvering RVs [reentry vehicles] that could evade future U.S. missile defenses" (2002, 9). Omitting or redefining certain items allows the PRC to "open the door" for other governments to either complete agreements or permit export licenses of precision technologies.

Unclear or irregular definitions in missile components are not the only problems in regard to terminology. Standards on missile terms do vary among public- and private-sector institutions. The Department of Defense (DOD) Joint Publications are a noteworthy attempt by the military community to define terms among all military branches; however, many terms are defined differently by outside organizations. For example, the MCTR Handbook defines CEP as "circle of equal probability," instead of the DOD term "circular error probable," which is used in this study (MCTR Annex 1998, 32). Wherever possible, DOD terms from *Joint Pub 1-02, Department of Defense Dictionary of Military and Associated Terms,* and *Joint Pub 3-01, Joint Doctrine for Countering Air and Missile Threats,* are referenced in this paper.

Confusing still are the number of export controls developed by the U.S. government, with primary regulating bodies coming from the Departments of State, Defense, and Commerce. Acts and regulations important to denying precision missile technologies include the Arms Export Control Act, the Export Administration Act (and the accompanying Export Administration Regulations, or "EAR"), and the Military Critical Technologies List (MCTL).

The Arms Export Control Act, administered by the Center of Defense Trade Controls in the Department of State, regulates the export of military equipment and services to include possible contractor advisors in support of U.S. foreign policy objectives. The Department of Commerce's Bureau of Export Administration oversees the licensing of technology transfers in accordance with the EAR, while the Department of Defense maintains the MCTL in order to identify technologies and data that counter or compromise technological advantages of the U.S. military.

One of the more important government documents that brought attention to illegal technology transfers from U.S. contractors to PLA front companies is the declassified 1999 U.S. Congress' Cox Report. This report detailed how the PLA organizes front corporations under the Committee on Science, Technology and National Defense Industry (COSTIND) (Cox 1999, 8). Importing front companies then transferred technologies to factories and research institutes, such as the China Aerospace Science and

Technology Corporation, that focus on dual military and civilian research, development, testing, and manufacturing. Of note is the priority placed by the PRC on precision-guided weapons to modernize the PLA (Cox 1999, 18). The Cox Report clearly outlines the relationship of the PRC's 16-Character Policy, which essentially combines and prioritizes military modernization with civilian reform, and asserts that the overarching strategic intention of this policy is for civilian efforts to support the military as "the key object of general economic modernization . . . and to support the aims of the PLA" (Cox 1999, 13).

The Cox Report also highlights the direct, extensive oversight of imported dual-use technology acquisition, embodied in the Super 863 program that was announced by the PRC in 1996 to continue acquisition and development of foreign technology (Cox, 12). In addition to technological policies, the report contains separate chapters on PRC satellite and ballistic missile technology, lapses in U.S. export controls, and the theft and acquisition of high-performance computers (HPCs).

The CIA has provided open-source and unclassified reports highlighting the PLA's missile development and acquisition activities. A report authored by Bates Gill and James Mulvenon provides detailed information on the 2nd Artillery Corps use of missiles in a campaign plan against Taiwan, and the status of PLA research activities in the development of ballistic and cruise missile technology.

Nonproliferation organizations that focus on reducing weapons of mass destruction have been the best reference for on-line material. Organizations such as the Nuclear Threat Initiative (www.nti.org), the Carnegie Endowment for International Peace (www.ceip.org) and the Center for Nonproliferation Studies (cns.miis.edu) maintain websites with research databases that contain chronological information, recent studies and papers, country-related missile studies, and missile testing updates. Although most nonproliferation websites have been available prior to 9/11, the amount of qualitative information and articles has increased, and many articles are written about nonstate organizations and the threat of WMD by terrorist organizations. Perhaps the foremost nonproliferation-based website is maintained by the Federation of American Scientists (FAS). The FAS website (www.fas.org) includes information on organizational missile units, congressional reports, arms control issues, and other information not listed by other organizations, including a listing of corporations that are involved in developing missile technology.

Other sources include government and private reports that are easily reached by the Internet. Sources such as the Strategic Studies Institute (SSI) and the Department of Commerce’s Bureau of Industry Security (BIS) provide published papers and regulatory information without charge. These sources are comparable to the information provided by other sites from a commerce perspective.

Although there are a significant number of authors and journalists reporting on the threats from terrorism and WMD, Bill Gertz’ articles and interest have provided more quantitative information about the PRC’s missile activities in the last decade. Serving as the defense and national security reporter at *The Washington Times*, Gertz has written three books related to the PRC missile threat: *How the Clinton Administration Undermined American Security*, *The China Threat: How the People's Republic Targets America*, and *Breakdown: How America's Intelligence Failures Led to September 11*. Gertz’ second book is an excellent reading on how the PLA committed resources to steal secrets such as nuclear weapons technology from the United States.

CHAPTER 3

RESEARCH DESIGN

Subjects

The PRC devotes significant resources to developing ballistic and cruise missiles to assert itself as a regional and global power. In FY2000, the PRC devoted 7 percent of the entire defense budget to its separate missile branch, the 2nd Artillery Corps. This is significant considering this percentage does not reflect procurement or research figures (Virtual Information Center *China's Defense Budget* 2000, 2). By examining the PRC's missile needs, recommendations for a technology ban can be developed in order to disrupt the PRC's acquisition of precision technologies. Since missile development remains a priority for the PRC, it is important to identify what capabilities are required for the 2nd Artillery Corps' newer systems. From analyzing five of the more advanced missile systems, precision technologies required by the PRC's missile programs are highlighted. Of the five systems, each is at a different phase of development.

As a benchmark, the liquid-fueled, mobile Scud missile serves as the point of departure from which these five missile programs differ and indicates what precision technologies are required to increase their ability to hit their targets. Used extensively in the last two decades of the 20th century, the Scud missile was a threatening symbol that leveraged political will for authoritarian regimes that were attracted to its use primarily due to its low cost and lack of credible defenses by an adversary.

Ballistic Missiles

China's ballistic missile programs include a variety of land- and sea-based missiles capable of supporting regional and global objectives, such as supporting an attack on Taiwan or acting as a nuclear deterrent against the United States. Although antiship missiles play an important role, the PLA's emphasis in the few years has been on the development and deployment of land-attack missile systems. The PRC maintains a number of silo-based ICBMs that are vulnerable to the high accuracy of U.S. ballistic missiles, and has embarked on developing missiles that are mobile, accurate, and based on their use of solid propellants, quicker to launch (Cox 1999, 192). These systems include the DF-11, DF-31, DF-41, and JL-2. The use of solid-fuel propellants in each of these systems is a significant departure from traditional, liquid-fueled SCUDs, as the logistics footprint is reduced while deployment time in the field is increased.

The DF-11 is a road mobile, solid-fueled, short-range missile that is essentially the Chinese version of the Scud missile capable of delivering a nuclear or conventional payload (FAS *China Nuclear Forces* 2000, DF-11). With an initial range of 300 kilometers and a CEP of 200 meters, the DF-11 variant was developed to increase the range to 1,000 kilometers and improve the CEP to less than 200 meters (Softwar *Dong Feng/Julang Series Missiles* 2002, 3). Currently, DF-11 missiles are deployed in China's southern provinces of Hunan and Fujian with the strategic intention of augmenting DF-15 missile employment against Taiwanese civilian ports and military facilities.

According to varied reports, the DF-11 and DF-15--also known as the M-11 and M-9 respectively--are upgraded missiles in the Scud B/C classification, and are closely related in size and technological specifications. Operated by the PLA's 2nd Artillery Corps, the DF-11 and DF-11 variant are contracted by the Academy of Rocket Motors Technology (ARMT) and the Sanjiang Space Group, respectively (FAS *China Nuclear Forces*, DF-11). Although still under development, the DF-11 variant is considered operational by some experts (ACA *World Ballistic Missile Inventories* 2002, 1). This variant differs in that it is a two-stage rocket (Swaine with Runyon 2002, 18).

The DF-31 is a road mobile, solid-fueled, ICBM capable of delivering a single thermonuclear warhead or three 90-kiloton warheads (Softwar *Dong Feng/Julang Series Missiles*, 8). With a likely range of up to 8,000 kilometers and a possible CEP of 300-500 meters, the DF-31 is designed to provide the PRC with a survivable, nuclear capability against targets in Hawaii, Alaska, and the western United States (Virtual Information Center *China's Strategic Nuclear Force* 2001, 8). Operated by the 2nd Artillery Corps at bases in Tai-Hang and Wuzhai, the DF-31 is contracted by ARMT and could be operational in late 2003 (FAS *China Nuclear Forces*, DF-31).

The DF-41 is a mobile, solid-fueled, ICBM capable of delivering a nuclear payload--possibly a single thermonuclear warhead or between three to six, 50-100 kiloton warheads (FAS, DF-41). With a likely range of 10,000 to 12,000 kilometers and a possible CEP of 700 to 800 meters, the DF-41 is designed to provide the PRC with a survivable, nuclear capability against targets on the continental United States (FAS, DF-41). Operated by the 2nd Artillery Corps, the DF-41 is contracted by ARMT and is expected to be operational by 2010 (FAS, DF-41).

The PLA made progress in sea-launched missile development commensurate with its naval capabilities. China's limited submarine force boasts two sea-launched ICBMs: the Julang 1 and Julang 2 ("Great Wave"). The JL-2 missile is a derivative of the DF-31, with an expected range of 8,000 kilometers and a possible CEP of 500 meters (FAS, JL-2). The JL-2 is contracted by ARMT, and is expected to be operational with the successful completion of the Type 094 submarine (FAS, JL-2). Because the Type 094 submarine is not planned for construction until 2004, the JL-2 test platform is a former Soviet Golf-class ballistic missile submarine (SSB) (Virtual Information Center, 13).

Ying Ji (Strike Eagle) Land-Attack Cruise Missile

China's cruise missile development program boasts a variety of antiship, air- and sea-launched cruise missiles, many of which are limited by short ranges. The missiles of concern are those that are capable of land attack. Currently, only one missile, the Ying Ji-22, is under development as a land-attack cruise missile (LACM). This missile is a derivative of the HY-4 Silkworm antiship missile, with a planned range of 135 kilometers and a possible CEP of 10 meters (Global Security 2002, C-802). Currently under development by the China Hai Yang Electro-Mechanical Technology Academy (CHETA, or 3rd Academy), the YJ-22 could be operational by 2005 (FAS, C-802).

Criteria

In order to identify precision technologies needed by the PRC, each subject missile must be assessed by two different criteria: one, the phases of missile flight for each system; and two, each missile program's progression. These assessments reveal not only a measure of the PLA's success, but also the critical technologies required to achieve successful development to deployment. In other words, the phases of delivery describe what the system needs, while the progression of the program details the effectiveness of the missile program in integrating required technologies. As related to precision technology, the criteria identify both purpose (needs) and process (status).

Phases of Missile Flight

For ballistic and cruise missiles, there are three phases of missile flight: the boost phase, midcourse phase, and the terminal phase. The boost phase is defined as "that portion of the flight of a ballistic missile or space vehicle during which the booster and sustainer engines operate" (JP 1-02, 56). During this phase, the missile receives information and is launched in order to successfully be on course to the target.

Precision technologies during the boost phase include propulsion components and equipment, composite materials, navigation equipment, avionics, and launch support. Propulsion typically requires a booster rocket and propellant, such as a first-stage rocket, to overcome the effects of gravity and inertia. Since ballistic missile systems in this study use solid fuel, composite fuels are mixed with oxidizers in precise ratios and cast, or "cartridge loaded," into fuel bodies that burn without outside air to produce missile thrust (MCTR, 64). Cruise missile propulsion, in the form of scramjets, ramjets, pulsejets, or gas turbojet and turbofan engines, requires a booster propellant to launch the missile. While navigation and avionics equipment such as integrated flight instruments, global positioning systems (GPS), and inertial measurement units (IMU) provide for greater accuracy by tracking and adjusting course throughout all phases of missile flight, launch support equipment play an important role in correctly establishing the flight path. Transporter-erector-launchers (TELs), with their mobility characteristics and on-board computer systems, are critical to calculating an accurate launch position and trajectory.

The midcourse phase is defined as "that portion of the trajectory of a ballistic missile between the boost phase and the reentry [terminal] phase" (JP 1-02, 273). This phase starts after the expenditure of fuel, during which the missile achieves a ballistic course to the target. The midcourse phase ends when the missile passes its flight apex.

The precision technologies during the midcourse phase include propulsion components and equipment, composite materials, flight control, avionics, ADCs, and in the case of cruise missiles (which do not go ballistic or reach an apex), any navigation systems required to verify or guide the missile along its course. Engines for cruise missiles are essentially smaller versions--in design and operation--of civilian aircraft engines, and make long-range delivery of payloads operationally practical (MCTR, 43). Flight control subsystems, such as attitude control and hydraulic equipment, steer a missile in order to achieve and maintain a stable flight or make corrections based on commands or sensor inputs from the guidance system (MCTR, 145).

The terminal phase is the final phase in "the trajectory of a ballistic missile between reentry into the atmosphere or the end of the midcourse phase and impact or arrival in the vicinity of the target" (JP 1-02, 435-436). This phase starts after the missile passes its apex and seeks to deliver its payload. During the terminal phase, a missile can achieve speeds greater than 3,200 kilometers/hour (or 888 meters/second) (Arms Control Association *U.S. Missile Defense Programs* 2002, 2).

The precision technologies during the terminal phase include propulsion components, composite materials, flight controls, avionics, and any navigation devices necessary for terminal guidance into the target. For ballistic missiles that essentially use solid-fuel, solid-fuel propulsion enhancers such as kick motors (which are used in satellites to make final corrections in orbit) can be added to direct or redirect payloads to their target during the terminal phase.

Missile Program Progression

The second criterion, missile program progression, closely resembles the phases of weapons development used in the United States. Each system is evaluated at its current phase of development: research and development, engineering and manufacturing, developmental testing, operational testing, and production and deployment. The missile program's effectiveness is assessed as the identification of incorporated technologies--as well as technologies that have not been successfully incorporated or are missing--becomes apparent.

The research and development phase is defined as the time in which basic concepts for a proposed missile system are debated and defined. Chapter 4 establishes the PRC's technological accomplishments in developing a system that supports a strategic objective of the PRC. An understanding of what the missile system was originally intended to do verifies success and achievement in successfully integrating technologies if the missile system reached this phase. During research and development, computer systems and modeling software are important to the design of advanced missiles systems.

The engineering and manufacturing phase is defined as the time during which systems are fabricated and assembled. If technologies are not available to meet design requirements or the manufacturing capacity to produce them do not exist, then acquiring the necessary systems through trade or espionage is necessary. It is in this phase that the importation of technologies by the PRC is most likely to occur. The term "reverse-engineered" denotes imported technologies that were acquired, studied, and then locally produced. A PLA missile program's success can be largely dependent upon the ability to reverse-engineer subsystems. Indeed, the PRC lags behind in the ability to produce precision machinery to make composite materials for missile components and bodies.

The developmental testing phase indicates success in completing design specifications of specific subsystems. Because experimentation is conducted on various parts of the missile system, developmental testing occurs throughout other phases.

Developmental testing commonly occurs in the form of testing missile bodies in wind tunnels, fielding engines on test stands, or modeling with advanced computer software.

Unlike developmental testing, the operational testing phase is conducted as an entire missile system under a variety of testing scenarios in order to simulate combat conditions. Operational testing is the marker of successfully developing a missile system.

Once a missile system completes operational testing, the weapon is fielded during the production and deployment phase, provided the missile system is still viable and the resources are available. If an adversary has developed a system to counter that missile's intended purpose, then the system may be abandoned, produced in limited quantities, or redesigned with upgraded or new technologies to overcome an adversary's measures. In order to produce a larger quantity of missiles and components, the PRC must have the capability to build, reproduce, or retool specific machinery on a large scale.

General Conclusions

Both phases of missile flight and program progression criteria provide an analysis of the five subject missile systems, and reveal the technologies that need to be developed or reverse-engineered. The key step in drawing conclusions lies in the framework of what the PRC can achieve in terms of missile parity, superiority, and supremacy. The PLA may have successfully developed and deployed a missile system; however, this does not necessarily mean that, weighed against missile defense systems from the United States and Taiwan, that it is effective enough to fulfill its intended purpose.

A logical conclusion is that the PRC already fields a large number of missiles to achieve a certain degree of missile dominance (missile superiority or supremacy). If the PLA is capable of producing, employing, and maintaining a large land-attack missile force, then target saturation alone, not advanced technology, could undermine an adversary's efforts to develop defenses to intercept those missiles. Certainly, a numerical mass of missiles launched at a specific target list produces a target saturation effect in which missile defenses are overwhelmed.

On the other hand, missile parity may not have been achieved due to limits in the industrial capability to develop, produce, and maintain a missile force with the required payloads. The missile program itself may be vulnerable if needed technology is denied. For instance, the sea-based JL-2 ICBMs require submarine platforms. Because Type 094 submarines are not completed, the JL-2 program could be frustrated if technologies and expertise are unavailable over a period of time in which adversaries such as Taiwan and the United States develop missile defense systems that make the JL-2 obsolete.

The use of a missile comparison chart in chapter 5 summarizes the comparative abilities of the PRC's short-, medium-, and long-range missiles against potential U.S.-Taiwanese missile defense systems, and addresses the less obvious conclusions. This assessment identifies those missile systems that cause concern as well as current and future technologies that the PRC requires to achieve missile parity, superiority, or supremacy.

Conclusions are drawn regarding the ability of the PRC to leverage technologies that are unavailable or require reverse-engineering. The thesis question is then answered one way or the other. Either the PRC must continue to seek foreign technology to complete development of its missile program, or it has achieved and completely integrated existing technologies to the point that a technology ban is irrelevant.

CHAPTER 4

ANALYSIS

In the last decade, missile technology has advanced far beyond the Soviet Scud missile, the battlefield successor of the German V-2. In the 1980s, Scud units targeted civilian populations and military facilities during such conflicts as Iran-Iraq (over 600 Scuds fired), the Libyan bombing of 1986 (two Scuds fired by Libya at a U.S. Coast Guard facility on an Italian island), and Afghanistan (over 2,000 Scuds fired at mujahedeen bases) (SDIO 1992, 7). However, these Scuds, with CEPs ranging from 450 meters up to 3 kilometers, incorporated inaccurate inertial guidance systems to guide a single warhead to a target (SDIO, 10). Since the first Gulf War, when Iraq fired approximately 95 Scuds against coalition forces, rapid developments in solid fuels, navigation, and composite materials along with computer-based designs have provided for greater accuracy, making the SCUD missile a nearly obsolete and less appealing system (Murton 1991, 3). The PRC's five advanced missile programs have precision technology requirements in these areas that are common for each missile program.

Precision Technologies Required during Theater Ballistic Missile Flight Phases

Smaller than the other four systems in size and range, the DF-11 variant requires upgrades used during the boost phase in order to be launched with a correct trajectory. Like all solid-fueled, self-contained missiles, the DF-11 variant requires solid oxidizers that are integrated into the solid propellant during production. Since the missile does not use outside oxygen, oxidizers are vital ingredients to the propellant that control the burn-rate of the fuel to achieve the required range (see Table 1). Solid fuels are advantageous over liquid fuels because they are easier to field. They do not require oxidizer trucks or supporting vehicles as those seen in liquid-fueled Scud brigades, providing a tactical advantage since an adversary's identification of support equipment can lead to locating and destroying missile launchers. However, solid-fueled rockets require machine tools that precisely mix oxidizers with the fuel as a dry propellant cartridge into rocket casings--particularly for more advanced, or "exotic," propellant additives and agents.

Table 1. Missile System Technologies Needed to Increase Accuracy

Precision Technology Needs	DF-11 Variant	DF-31	DF-41	JL-2	YJ-22
Boost Phase	Solid-fuel Propellants & Machinery Composite Materials & Machine Tools TEL-based GPS	Improved TEL chassis TEL-based GPS	Improved TEL chassis TEL-based GPS	ICBM launch capable Submarine	Land-Based, Mobile Launcher Fuel-Efficient Engine
Midcourse Phase	GPS Guidance Corrections		Hardened ADC		GPS guidance Digital Mapping
Terminal Phase	Kick Motor Technology	Nose Cone Heat Shield MIRV Dispenser MIRV Guidance System	Nose Cone Heat Shield MIRV Dispenser MIRV Guidance System	Nose Cone Heat Shield MIRV Dispenser MIRV Guidance System	TERCOM Computer Components High-Resolution Imagery

Lightweight, composite materials provide a significant capability for overcoming the forces of inertia and gravity, increase range, and allow guidance and control systems to easily steer the missile along its proper trajectory. Unlike the DF-15, the DF-11 variant could use lighter materials to allow for a larger payload. However, composite material production for developing missile bodies, rocket motor cases and linings, or other components of the missile requires precision machinery and the capability to produce advanced, fibrous materials.

In terms of launch support and navigation equipment, the mobile DF-11 variant needs a Scud-like TEL. If these TELs are enhanced with GPS, then launch position accuracy is increased without the need for a pre-surveyed site. Knowing the precise launch location using GPS is important for two reasons: one, the TEL is properly aligned with the missile's intended trajectory; and two, a GPS-surveyed site takes little time to verify location as opposed to a ground-surveyed site, manually done by the crew. This is critical to reducing the time exposed to an adversary's attack systems while providing greater flexibility and responsiveness to targeting changes.

During the midcourse phase, a significant departure from Scud systems is the use of improved avionics in the form of GPS to contribute to the guidance of the missile to maintain its proper trajectory. Prior to the introduction of satellite-based positioning, Scud missile guidance used internal navigation systems (INS) that relied on launch position, the effects of gravity, and time to maintain trajectory. The PRC intends to use some form of GPS on its short-range missiles "which likely include the [DF-11 variant]" to increase missile accuracy (Cox 199, 188). Because GPS receivers detect satellite radio signals that contain accurate time and position of at least three satellites, the GPS receiver determines the position and the velocity of the missile by measuring the signal delay between the satellites (MCTR, 156). In conjunction with a guidance set, this information is transmitted to the DF-11 flight controls so that the missile proceeds accurately along the flight path. Unlike SCUD missiles, which use only accelerometers and gyroscopes

(INS) to detect variations of the current trajectory from the preprogrammed flight path, GPS-like systems increase accuracy by transmitting positional information for the flight computer to compare against the preprogrammed path. Such navigation systems could improve the inertial-based DF-11 CEP from 200 meters down to as little as 40 meters.

During the terminal phase, the DF-11 variant may incorporate a solid-fuel kick motor to thwart missile defenses by changing missile direction and speed upon reentry. Used in conjuction with a guidance system that can properly measure and control the thrust and vector, the kick motor could present a false trajectory during the previous phases, and then adjust its final path after a missile defense system has been committed to intercept the DF-11 variant along the previous path.

Precision Technologies Required during Intercontinental Ballistic Missile Flight Phases

As ICBMs, the DF-31, DF-41, and JL-2 differ significantly in design and purpose from the DF-11 variant, yet require similar technologies, such as solid-fuel propellant and GPS navigation, to improve accuracy. Because the PRC's limited silo-based ICBMs are vulnerable to attack, the 2nd Artillery Corps is developing road-mobile ICBMs that are more difficult to find, as evidenced by the results of Desert Storm, where the United States outperformed Iraq in every facet except in locating mobile Scud TELs.

A mobile ICBM force provides the PRC with both a preemptive and survivable counterstrike nuclear capability. Because DF-31 and DF-41 ICBMs are larger and heavier than traditional Scuds, they require significant improvements in TEL chassis design for cross-country mobility. In addition, TELs with GPS would increase their capabilities and ensure greater accuracy, particularly if those systems are used to attack ports and military staging bases in the Pacific Rim.

Unlike the road-based DF-31 and DF-41, the JL-2 uses a submarine as its launch vehicle. Currently, the JL-2, based on the DF-31 missile, can achieve the same results, provided the PLA Navy can field a submarine capable of launching ICBMs. This system would provide the PRC with a mobile, sea-launch capability that could operate from waters outside the territorial area, thus expanding ICBM ranges over the entire continental United States. As a nuclear system targeting cities, the JL-2 would not necessarily require a significant improvement in GPS guidance to increase its CEP.

Any missile that has a computer requires an ADC. ADCs convert analog signals (electronic) to digital data in the patterns of "1s" and "0s," which are then sent to the computer to read and respond to (MTCR 1998, 182). ADCs are common and allow sensor outputs from such components as accelerometers and gyroscopes to be read by digital computers. In the midcourse phase, ADCs play a key role in translating signals for trajectory information and control. Unlike the DF-11 variant, which will likely remain in the atmosphere during flight, ICBMs need ruggedized and hermetically sealed ADCs capable of withstanding temperatures in the exoatmosphere, and have a much faster processor speed (8 bits or over is defined as deniable for export by the MTCR). In addition, these ADCs must be hardened against the effects of blast radiation.

With the acquisition of U.S. designs for smaller nuclear warheads, the PRC is expected to exploit this capability in conjunction with its mobile ICBMs. The acquisition of the W-88 warhead design allows the PRC to proceed in the development of larger payloads and create mulitple independent reentry vehicles (MIRVs). In the terminal phase, MIRVs (with payloads) separate from the missile, and are launched at multiple targets, making interception by missile defenses during the terminal phase difficult. These dispensers, or buses, require a separate guidance and payload release system.

Due to the extreme temperature and pressure changes that ICBMs must endure during the terminal phase, composite materials are required in order to develop a heat shield, or nose cone fairing, to protect the multiple warheads and bus. The PRC must have the capability to manufacture fibrous materials, coatings, ceramics, and metal-plastic composites in order to develop an effective heat shield. Such materials prevent the missile from disintegrating as it reenters the atmosphere.

Precision Technologies Required during Cruise Missile Flight Phases

Unlike ballistic missiles, cruise missiles do not follow a ballistic trajectory to the target. The YJ-22, the PRC’s first LACM, will have certain advantages over ballistic missiles and aircraft. First, the YJ-22 will likely be cheaper to produce, possibly up to one-third the cost. The president of the China Hai Yang Electro-Mechanical Technology (CHETA) noted that “the cost of producing cruise missiles is 20 to 30 percent less in China than it is in other countries” (Gill and Mulvenon 1999). Second, cruise missile production costs allow program managers to allocate funds to develop GPS systems, or terrain contour matching (TERCOM) guidance that will allow cruise missiles to travel close the ground and under air defense coverage. Finally, cruise missiles do not act in the same manner as ballistic missiles do during traditional boost, midcourse, and terminal phases; hence, cruise missiles do not undergo extreme temperatures or require hardening, or the degree of ruggedization, of components required for ballistic missiles. Most of the expertise and technological points of reference come from the Chinese Silkworm antiship cruise missile program.

Although solid-fueled rocket motors could be installed in the cruise missile, limitations caused by weight and flight path would limit the range. An engine is preferred, since the outside air is being used instead of incorporating an oxidizer into the fuel. Because the YJ-22 will fly low and within the atmosphere, the weight required for an oxidixers can be used to carry more fuel. As a matter of range, the more fuel efficient the system, the greater the range and flight path capability of the missile.

Like ballistic missiles, cruise missiles require a launcher that maintains cross-country mobility, rapid movement, and quick reload. GPS-based launchers are again important, since the INS and additional guidance system would require correct launch point information to ensure a higher CEP. GPS-equipped launchers allow cruise missile firing units more flexibility, and will not need pre-surveyed sites to fire and move rapidly. In addition, a lower infrared (IR) launch signature and a lower transport weight gives cruise missile systems advantages over ballistic missile units (Gill and Mulvenon 1999).

En route to the target, the YJ-22 is expected to use GPS/INS for midcourse guidance and TERCOM for terminal guidance to the target (Liao 2000, 8). Programming the missile requires remote sensing (satellite) imagery and a flight computer that can use digital mapping data to accurately guide it to the target. Digital mapping such as digital terrain and elevation data (DTED), which accurately portrays geographic information with updated intelligence on known enemy missile defenses and targets, could be programmed and compared to images the seeker acquires en route to guide the missile to the target. Detailed satellite imagery and mapping data is important for missile accuracy, as terminal guidance requires high-resolution and update imagery on the intended target.

Ballistic Missile Program Progression and Precision Technologies

DF-11 Variant Progression

As a theater missile designed to support operations against Taiwan, the DF-11 variant improves upon current DF-11s and DF-15s by providing greater ranges (1,000 kilometers) for launching deeper within the protection of the PRC's southern provinces, while increasing missile accuracy (CEP of 200 meters). The DF-11 variant is based on an original missile design from 1975, with research and development completed in 1984 (FAS *China Nuclear Forces*, Contractor). Research and development of this missile was done at the Sanjiang Space Group's Base 066, although the China Academy of Launch Technology (CALT, or 1st Academy) is responsible for research and development of most ballistic missiles (Cox 1999, 231). The original DF-11 made its first appearance at the Beijing air show as a two-stage missile advertising a 1,000-kilometer range in 1987; however, operational DF-11s are single-stage missiles with a range of 300 kilometers (FAS *China Nuclear Forces*, DF-11).

Overall, the DF-11 variant is currently in the developmental testing phase (see Table 2). Unlike the single-stage DF-11 and DF-15 missile brigades under the 2nd Artillery Corps, future DF-11 variant units will deploy a two-stage rocket system. While it is unclear if the DF-11 variant has specifically tested the two-stage system, the PRC has achieved deployment capability in multi-stage systems, as evidenced by its success in launching both commercial and military satellites systems into space using two-stage rockets. This technology was probably shared by the Beijing Institute of Control Devices, which is responsible for both ballistic missile and space rocket designs (Cox 1999, 231). The DF-11 two-stage system has, at least, surpassed the engineering and manufacturing phase, not only because the PRC's space and missile programs are closely linked, but also because developing space launch vehicles are more complicated than developing short-range systems or ICBMs.

Table 2. Missile System Technologies Progression by Phase

Missile System	Research & Development	Engineering & Manufacturing	Developmental Testing	Operational Testing	Production & Deployment
DF-11		Multiple-Axis Machines Capable of Incorporating Advanced Composite Materials	2-Stage Rocket Design Incorporated with Solid Fuel Propellants Midcourse GPS Guidance	Kick Motor Technology	TEL-equipped GPS
DF-31		Nose Cone Fairing (Heat Shield) Composite Materials	Improved TEL chassis	MIRV Dispenser MIRV Guidance System	TEL-equipped GPS
DF-41	Incorporating Advanced Composite Materials into Missile Design (to include Heat Shield) Hardened ADC	3-Stage Rocket Design Incorporated with Solid Fuel Propellants	MIRV Dispenser MIRV Guidance System Improved TEL chassis		TEL-equipped GPS
JL-2		Nose Cone Fairing (Heat Shield) Composite Materials Type 094 Submarine		MIRV Dispensier MIRV Guidance System	
YJ-22		Multiple-Axis Machines Capable of Incorporating Advanced Composite Materials	GPS Launch & Midcourse Guidance TERCOM Guidance & Digital Mapping Technology	Land-based Launcher	Production capability to produce advanced jet engines

Red=Unavailable, Yellow=Under Development or Uncertain, Green=Ready

However, in terms of solid-fuel propellant technology, it is uncertain if the Sanjiang Space Group, which specializes in solid-fueled ballistic missiles, has integrated two-stage rocket designs with solid-fuel propellant control systems. What is clear is that the corporation has achieved success in production and deployment of single-stage, solid-propellant ballistic missiles, as evidenced by reports over that last two years that DF-11 missile shipments have been spotted moving by rail from factories in Yuanan, located in western Hubei province, to 2nd Artillery Corps missile bases at Yongan and Xianyou that are within firing range of Taiwan (Gertz 2001). These reports are corroborated by the location of at least six factories owned by the Sanjiang Space Group in Yuanan, where the corporation's production facilities are based (FAS *China Nuclear Forces*, Contractor). The corporation can be expected to integrate lessons learned from other multi-staged and solid-fueled missile systems into the DF-11 variant.

Although the Sanjiang Space Group owns metalworking machinery, it is improbable that advanced composite materials have been integrated into the DF-11 variant's design. The PRC does not have the capability to produce precision, multiple-axis machines, as well as computer-aided design tools, that are necessary to integrate lighter, but stronger advanced composites into component structures. According to a 1999 report, "sophisticated robotic machines--some as many as nine axes of motion–[that] are required to make missile body composites" were not available in the PRC and remain a highly-sought PLA technology requirement that is banned by the MCTR (Cox 1999, 157). The 2002 release of the PRC's own export control list glaringly omits "multidirectional and multidimensional (axes) weaving or interlacing machines, including adapters and modification kits for weaving, interlacing or braiding fibers to manufacture composite structures," indicating the PRC does not recognize such important machinery as items that should be prevented from being acquired on the international market (Saunders 2002, 6). This is a possible decision point for the DF-11 variant program, and it is likely that the two-stage missile will be tested without composition materials, instead relying on propellant thrust from the two-stage rocket to provide improvements in payload weight and effects. Otherwise, further missile system development could be delayed up to a decade, pending the acquisition of such machinery.

Despite increases in load capacity, the TEL design--based upon the four-axle (eight-wheeled) Soviet MAZ-543 originally produced by the Minsk Automotive Factory in Minsk, Belarus, during the 1960s--will not need any major improvements in the chassis or carrier design. However, the reverse-engineered PLA version will likely incorporate GPS navigation aids to provide the missile with accurate launch point and flight path information. Launch information could come from handheld GPS receivers, or be electronically integrated into the TEL's computer itself.

Separate from an indigenously-produced Chinese satellite navigation system, the PRC has the ability to receive information from both the U.S. GPS or Russian Global Navigation Satellite System (GLONASS). Though both systems are operational, the GLONASS system has detoriated to only a reported eight of twenty operational satellites, while the U.S. GPS system has twenty satellites operational with four spares. Although the PRC has signed agreements with Russia to use GLONASS, the system's further deterioration leaves its reliance on it for military applications in doubt.

After the downing of a Korean Air Lines (KAL) flight by Soviet fighters in 1983, the GPS system was made available for commercial use, requiriing four satellites (three in the horizontal plane and one in the vertical plane to calculate altitude) to deliver time, position, and velocity information to an accuracy of 100 meters or less. Known as Course Availability (C/A) code, it was realized that the code actually delivered accuracies to within 40 meters, and the United States introduced Selective Availability (S/A) to reduce the accuracy, while developing a precision (P) code for military receivers.

Although GPS receivers in missiles with flight speeds exceeding 1,000 nautical miles per hour are banned for export by the MTCR, providing information for launchers is not explicitly banned (MTCR, 156). Since commercial receivers are easy to acquire, handheld GPS information can easily be obtained and programmed into the missile prior to launch, provided the missile has a manual or electronic means of inputting that information into the flight computer. The PLA understands the capability of commercial handheld GPS, as evidenced by omitting it in its own 2002 export control list. This suggests that the PRC does not recognize a foreign government's right to deny licenses to export such precision technology, as GPS can be used "in conjunction with attitude sensors to improve missile pointing accuracy" (Saunders 2002, 10).

For midcourse guidance accuracy, the PRC possesses GPS know-how and, at least, U.S. products such as commercial Trimble Navigation GPS receivers. These receivers were exempted from all licensing requirements by the Clinton administration and sold to the China National Aero-Technology Corporation (CATIC) in June, 1997 (Timmerman 1997, 34). Although Trimble claimed these receivers were not rugged enough for use in ICBMs, their ability to work up to 60,000 feet at pressures up to 4g made them suitable for cruise missiles, not to mention the lower-altitude trajectory that the DF-11 variant could be expected to fly.

In late 1996, Rockwell announced plans to form a company to design, develop, and build commercial GPS navigation receiver systems with Chinese partners in Shanghai (BEA 1999, 60). This was a joint venture with the Shanghai Avionics

Corporation and the Shanghai Broadcast Equipment Factory (Softwar MARV, 2). The Shanghai Broadcast Equipment Factory is a subordinate element of the Shanghai Academy of Spaceflight Technology (SAST, or 8th Academy), which oversees the development of components for rocket inertial guidance, stabilization systems, and telecommunications engineering, as well as propellant, engines, and rocket motors (FAS *China Nuclear Forces*, Contractor). Since one of the primary purposes of joint ventures is to share technology, it can be reasonably expected that GPS receiver technology in the form of design, fabrication, and assembly was shared with the PLA corporations.

Combining GPS with INS makes an integrated, more accurate IMU, or guidance set. Because INSs themselves contain errors, midcourse GPS devices are an excellent means of ensuring accuracy. The DF-11 variant has a mature guidance system with an IMU that has been tested on more than 50 flights of DF-11 and DF-15 missiles (Cox 1999, 229). Given the emphasis by the PRC to develop GPS technologies in the last decade, it is likely that the DF-11 variant will integrate GPS with this IMU. The extended range of the missile (from 300 kilometers to 1,000 kilometers) would not compromise the accuracy, and indeed, the missile could achieve CEPs better than 200 meters. Such an IMU is probably ready for developmental testing.

The PRC has likely operationally tested solid-fuel kick motors to thwart missile defenses in the terminal phase. In order to change the direction and speed of a missile's reentry path, a kick motor must have a guidance system to accurately guide the payload to the target. Interestingly, the guidance system used on the DF-11 is also used on the PRC space satellite Smart Dispenser (Cox 1999, 229). Such a system could frustrate radars that are providing final information to guide missile defenses during intercept.

In May 1995, U.S. contractors from Martin Marietta assisted the Chinese in correcting a solid-fuel kick motor that had only been tested once before in a failed launch of a Pakistani satellite. The correction involved completing coupled load analysis and alleviating concerns that the propellant "have exactly the right grain structure and be shaped to produce exactly the right amount of thrust for exactly the right amount of time" (Softwar *MARV Deployment* 2000, 1). The PRC space and missile program suffered setbacks in this area previously, but Martin Marietta's the assistance allowed the PRC to successfully push satellites into final orbit. The dispenser later positioned joint-venture satellites into orbit, suggesting that the independent guidance system worked.

There may be evidence that kick motors have been used in the DF-11 variant. Although it is widely accepted that DF-15 missiles have been fired in the Taiwan Strait in the last decade, the PRC may have operationally tested kick motor technology with the DF-11. In 1996, Aegis cruisers observing missile firings in the strait noted that the PRC's missiles did not follow a ballistic trajectory as other monitored launches of the DF-15; in fact, the warheads "changed directions and sped rapidly" (Softwar, 1). According to some reports, DF-11 variant missiles, not DF-15s, were launched by the 2nd Artillery Corps from the No. 2054 base in Hunan Province (FAS *China Nuclear Forces*, DF-11).

DF-31 ICBM Progression

The DF-31 ICBM was designed to replace the PRC's aging CSS-3 silo-based force with a more mobile and less vulnerable system. With a range of up to 8,000 kilometers and a CEP between 300 and 500 meters, the DF-31 ICBM's mobility will offset the numerical disadvantage of U.S. nuclear systems by narrowing "the qualitative gain . . . in terms of deterrence, [so that] there is not any difference in practical value" as a survivable counterstrike system (Central Military Commission *Changes in the Relationships with Taiwan* 1999). This message was deliberately represented to the United States, when the DF-31 was successfully fired from the Wuzhai Missile and Space Center on November 4, 2000, during General Hugh Shelton's visit to China (NTI *Nuclear Delivery System Modernization*).

The PRC can be expected to have manufactured and developmentally tested improved TEL designs for the DF-31. The PRC's longstanding relationship and resulting designs based on former Soviet Bloc equipment are exemplified by the TEL designs. Improvements in the DF-31 launcher are likely made or reverse-engineered from TELs used to launch former Soviet ICBMs. In 1996, the PRC imported a MAZ mobile launcher six-axle chassis, which was photographed at the Beijing Nanyuan missile plant (NTI China Profiles Database). The TEL, previously designed to launch Soviet SS-20 ICBMs, was delivered by Belarus (Gertz 1997, 9). This TEL was likely studied and reverse-engineered by the 15th Research Institute, the Beijing Institute of Speical Engineering Machinery. As a subordinate element of CALT, the 15th Research Institute specializes in ground communication equipment, launch control and missile launcher survivability.

Although it is unknown if this TEL design has been incorporated in the DF-31 missile firings, it can be reasonably expected that other institutes involved in ground vehicle design probably studied and reverse-engineered the TEL chassis for the DF-31. The chassis provided the Chinese with all-wheel independent suspension; higher ground clearance; driver-controlled central tire inflation and deflation systems; and large-diameter, wide-profile, variable-inflation tires (Gertz, 9). The DF-31 TEL will likely be outfitted with GPS receivers to improve launch accuracy and ballistic trajectory. Since the PLA is exceptionally familiar with former Soviet MAZ designs and engineering processes, the improved TEL chassis is at least ready for developmental testing.

It is unlikely that advanced, composite materials have been designed into the DF-31 missile body itself, with the exception of the nose cone fairing (or heat shield). It is the terminal phase of the DF-31's employment that is the key to completing this system. The achievement of smaller warheads, MIRV technology, and a heat shield to protect the MIRV bus, will allow the DF-31 to be fully produced and employed.

The highly publicized PRC espionage activity in acquiring the U.S. W-88 warhead (and its subsequent reverse-engineered design) in the last decade provided the PRC with the potential to develop MIRV warheads. Because these advanced, thermonuclear warheads are significantly smaller than those the PRC's silo-based missiles are designed to carry, it is possible for the PRC to develop and deploy ICBMs with MIRV technology (Cox 1999, viii). The PRC also demonstrated the capability to indigenously build MIRV technology by designing the Smart Dispenser satellite system in accordance with Motorola's design specifications to put two Iridium communications satellites into orbit (Cox 1999, 196).

However, on January 4, 2001, the *Washington Times* reported that a failed test launch occurred the previous day involving a space booster, used as a reentry vehicle on the DF-31, exploding in midflight. This test showed that the ICBM is being mated with MIRV technology (NTI *China Profiles Database*). The failure, coming after a number of successful DF-31 rocket engine tests and missile launches, also suggests that the PRC has not completed testing a heat shield for reentry.

Evidence indicates that the PRC lacks the indigenous capability to manufacture heat shields for MIRV reentry. As discussed earlier, the PRC's own export control list, released in April 2002, omitted multidirectional and multidimensional (axes) weaving or interlacing machines (Saunders 2002, 6). In addition to rocket casings and bodies, these dual-use machines are used to make "critical missile parts such as reentry vehicle nose tips and rocket nozzles that are exposed to high temperatures and stress" (Saunders).

That the PLA is having difficulty in developing a MIRV capability is further evidenced by its omission of navigation equipment such as high-acceleration gyros and accelerometers in the PRC's missile export control list, since these systems "could potentially be used as fuses in re-entry vehicles [RVs] . . . and in guidance sets that steer maneuvering RVs as they evade defenses or terminally guide themselves to a target" (Saunders 2002, 9). Together with the failed test, the PRC has not operationally tested a MIRV bus guidance system in the terminal phase.

DF-41 ICBM Progression

The DF-41 is designed to replace the longer-range CSS-4 silo-based force with a more mobile and less vulnerable ICBM capable of a 12,000-kilometer range. Unlike the DF-31, evidence suggests the DF-41 is in the research and development phase, as its longer range and payload delivery requirements will require improvements in solid-fuel technology, missile body design, and MIRV technology.

Although the DF-41 missile program was started in July 1986, the missile has not been flight tested in the last decade (Gill and Mulvenon 1999). This suggests improvements in missile body design with composite material technology, such as ablative coatings against missile laser defenses, could be added to the DF-41. Throughout the last decade, the PRC sought to acquire foreign ICBM designs, as evidenced in January 1996, when three Chinese workers in the Ukraine were arrested for attempting to smuggle ICBM designs from that country into China (NTI *Chinese Missile Imports*). In mid-November 1999, computer simulations were still being conducted on the DF-41's design, indicating the missile system was progressing in the research and development phase (Varner *China's Superpower Challenge* 1999, 3).

The extended range over the DF-31 by 4,000 kilometers requires the incorporation of propellant technology to the three-stage design. According to the MCTR, the PRC produces bonding agents, which bond the oxidizer to the fuel substance to form the solid-fuel cartridge (MTCR 1998, 76). Although the PRC produces most of the solid-fuel propellants needed for missile engines, it does not produce the exotic substances or bonding agents needed to increase efficiency and range (MTCR 1998, 69). The PRC's own missile export control list omits such chemicals, suggesting it not only does not produce them, but also does not consider it a violation to acquire or export it from another country. Although the PRC has shared engine propellant technology with Russia for decades and, since 1985, with Brazil, it is unclear what impact, if any, this relationship will have on the DF-41 program (NTI China Profiles Database).

It is uncertain if a mobile ICBM with a 12,000-kilometer range is possible with the PRC's current rocket technology, but evidence suggests research is ongoing to improve the rocket system. In 2000, the PRC announced the formation of a new solid-fuel rocket company, the Space Solid Fuel Rocket Carrier Company, in order to not only market current solid-fuel propellant and the Dong Feng series rockets for commercial launching of "microsatellites that are under 300 kilograms," but to also research and develop solid-propellant rockets as well (SpaceandTech.com 2000 *Space and Tech Digest*). Such improvements would directly benefit the DF-41 program.

Both the DF-31 and DF-41 require lightweight IMUs in their guidance systems, and the experience gained from the failures of the Long March 3B space launches in the last decade will benefit those designs (Cox 1999, 230). MIRV development and guidance expertise can be expected to come from both the DF-31 and the PRC's space programs, and they will likely be incorporated into the DF-41 during developmental testing.

For the DF-41, a more ruggedized and hardened ADC will be developed. The PRC is seeking a more capable ADC for the DF-41, as evidenced by its own definition of ADCs to not be exported or denied a license for import by a foreign government as ADCs with "an accuracy exceeding 1/10,000" (or 13-14 bit resolution, compared with 8-bit the MTCR) (Saunders 2002, 11). This suggets that the PRC is in the market for more accurate and ruggedized ADCs designed to handle the temperature extremes in the exoatmosphere as well as process signals quickly in relation to the increased speed of the ballistic missile by translating a mechanical gyroscope's analog signal faster and with less error (Saunders 2002, 11). Since computer systems are widely exported, it is likely the PRC will acquire hardened ADCs for the DF-41.

The JL-2 ICBM Progression

The JL-2, which is the sea-launched version of the DF-31, closely parallels the DF-31's progression with the exception of the launch vehicle. The most important objective in the JL-2 ICBM program confronting the PLA Navy is not so much the missile itself as it is the submarine, known as the Type 094.

Over the last decade, significant assistance from the Russian government in the form of equipment and propulsion system expertise has been devoted to the PRC's (as well as India's) naval propulsion programs (CIA *Unclassifed Report to Congress* 2002, 21). The JL-2 launch platform, the Type 094, is currently under construction at the Huludao Shipbuilding Factory in Liaoning province and could possibly be ready for deployment by 2004 (Virtual Information Center 2001, 13). The Type 094 will incorporate updated guidance technology that will enable the JL-2 to perform much in the same manner as the land-based DF-31.

Currently, JL-2 missile testing has been accomplished using a Golf-class SSB from the former Soviet Union, that was refitted in 1995 (Virtual Information Center 2001, 13). The JL-2 was successfully fired from this submarine in January 2001, one month after the DF-31's third successful missile firing in December 2000 (NTI China Profiles Database). Launching system technologies tested on this submarine will cut sea-trials and operational testing time on the Type 094. It is unknown how many Type 094s will be built by the PRC, but it is likely the numbers will be small due to the expense involved in building, operating, and maintaining a fleet of ballistic missile submarines.

Cruise Missile Program Progression and Precision Technologies

Perhaps one of the most dangerous developments in the PRC's military arsenal is the YJ-22 LACM program. The demonstrated use of LACMs by the United States in the last decade in Iraq, Afghanistan, Sudan, and Yugoslavia, coupled with the lack of a credible cruise missile defense by any potential adversary of the PRC, energized the PLA to develop an LACM, with the design initially based on the indigenously produced and widely exported HY-4 Silkworm antiship cruise missile (ASCM). Some reports suggest the PRC has made significant improvements in its cruise missile program, with several indications that Russian assistance and technology closely parallel Tomahawk designs (Dorminey 1999). In addition, reports indicate that the PRC has received and shared advanced cruise missile technology with Israel by contributing financially to that nation's development of its Star-1 LACM (NTI Chinese Missile Imports). Given the planned range of over 135 kilometers and a CEP of 10 meters, the YJ-22 would provide the PLA with a comparable theater and strategic capability as a deterrence factor or a credible threat against Taiwan (Liao 2000, 8) once the range is increased.

It is likely that the YJ-22 program has a launcher system ready for operational testing, based on the Silkworm shore battery organization. A first-generation LACM brigade could adopt an organization structure similar to today's typical HY-4 fire unit--four towed launchers, a firing command vehicle, a truck-mounted microwave relay, and an auxiliary power truck (Gill and Mulvenon 1999).

While the HY-4 uses a turbojet engine after a solid-fuel booster initially fires it from the launcher, the PRC is likely to incorporate a better engine based on U.S. technology to take over for the duration of the flight of the YJ-22. The interest in precision (cruise) missile engines began in 1990 when "the PRC attempted to advance its cruise missile program by purchasing the Williams FJ44 civil jet engine . . . derived from the turbofan jet engine that powers the U.S. Tomahawk cruise missile" (Cox 1999, 127). From 1992 to 1996, over fifty-nine gas-turbine Garrett engines were illegally sold by Allied Signal to the Nanchang Aircraft Manufacturing Company, and reverse-engineered copies have been reported to have been incorporated into the HY-4 (Cox, 137). However, even if the PRC has reverse-engineered the Garrett engine, it still lacks indigenous production capability to further develop advanced engine technology, making cruise missile engines a high priority for acquisition (Cox, 123). Certainly, the PRC would have needed assistance to build a production facility to manufacture cruise missile engines for its LACM, which was its "main interest in acquiring a production capability for the engines; thus, it halted further orders of the Garret Engine from Allied Signal when co-production plans were scuttled" (C-SPAN 1999, 7).

In 1995, the PRC also acquired assistance from the United Kingdom in developing a digital engine control for their K-8 aircraft trainer. This digital engine control is also important for guiding long-range cruise missile engines (NTI Chinese Missile Imports). Since this coincides with cruise missile development at that period, the PRC has probably engineered better engine controls to accurately guide cruise missiles.

Perhaps the most important system that defines a cruise missile is the accuracy of its guidance system. The PRC understands the importance of both GPS and TERCOM guidance in cruise missiles, having inspected a Tomahawk missile that crashed en route to Afghanistan in 1998, at the invitation of its missile trading partner, Pakistan (Cox 1999, 143). There are indications the PLA has already mastered use of GPS for midcourse corrections. Just as in a ballistic missile, accurate satellite data allows a cruise missile to receive regular midcourse updates that counteract the drift inherent in traditional gyroscope-based INSs. At least two tests of an on-board GPS trajectory reference system have been conducted as of 1995 (Gill and Mulvenon 1999). In addition, the PRC has produced and deployed an indigenous GPS system, known as Twin Star. On October 31, 2000, the PRC launched its first navigation satellite, the Beidou 1 (or "Big Dipper" 1), and then launched Beidou 2 on December 21, 2000, thus completing its initial requirements for a geo-based satellite navigation network (SpaceandTech.com 2000, *Space and Tech Digest*). Developed by the Research Institute of Space Technology, the Twin Star system provides regional coverage to China's transportation system and is expected to deploy over thirty satellites by 2006 to likely expand its coverage worldwide and make the PLA independent of U.S. or Russian navigation systems (SpaceandTech.com 2000). It is likely that the YJ-22 will be tested to operate using the PRC's indigenous navigation system.

For terminal guidance to the target, CHETA has been conducting preliminary research into TERCOM since at least 1988, and Chinese engineers note that the increasing availability of digital mapping technology, to include large-scale and very-large-scale integrated circuits (LSIC/VLSIC), has increased the interest in fielding TERCOM into an LACM (Gill and Mulvenon, 1999). As early as 1992, the PRC acquired technology that, under the 16-Character Policy, could be used to improve its missile guidance programs. An example of this is the purchase of an electron beam machine from Toshiba of Japan that could be used in developing special control systems and imagery for cruise missile navigation (NTI Chinese Missile Imports).

The most advanced PLA technology under development is digital scene matching area correlation (DSMAC), which is used to update the position of the missile by matching a stored image to a series of images sensed in flight (Gill and Mulvenon). By using photographs or high-resolution satellite imagery (to include purchasing imagery from commercial sources such as France's SPOT system), this data would then be converted into a digital image and loaded onto the LACM computer. CHETA engineers believe en route and terminal mission planning systems can ensure a CEP of 16 meters or less (Gill and Mulvenon).

Other Missile-Supporting Technologies

During the last decade, the PRC actively sought to acquire precision machine tools, test equipment, and high performance computers (HPCs). These technologies are used to design, engineer, manufacture, and produce composite materials for its weapons systems. This suggests a significant lack of precision design and manufacturing capability for its missile programs.

One of the most controversial episodes involved the PRC's purchase of nineteen multiple axis machines from the McDonnell Douglas company in order to produce airframe parts in a joint venture to produce the PRC's civilian aircraft program. In September 1994, the Department of Commerce approved the sale, but the Defense Intelligence Agency (DIA) noted that the large number of tools were not necessary for the limited number of airframes to be produced by the PRC (Cox 1999, 85). The sale was especially suspect, since these machine tools were used previously in a plant in Ohio that, along with the B-1 bomber and C-17 transport, produced parts for the Peacekeeper missile (Cox, 90). In April 1995, the U.S. Government learned from McDonnell Douglas that six of the licensed machine tools had been diverted to the Nanchang Aircraft Manufacturing Company, which was not involved in the civilian program, but was involved in making parts for the C-801 Sunburn cruise missile (Cox, 81).

The PRC continues to struggle in the development of HPCs to be used in the design and development of missile systems, although the MTCR makes no specific mention of HPCs. During the latter half of the last decade, the PRC took advantage of relaxed U.S. export controls on the sale of HPCs (computers in the speed range of 1500-40,000 millions of theoretical operations per second, or MTOPS), starting with virtually no HPCs in 1996 to over 600 of U.S. origin by 1998 (Cox 1999, xxx).

The PRC has made the development of HPCs a top priority, but still lags behind in indigenously producing HPCs. As a result of joint-ventures with foreign computer and semiconducter companies, the PRC continues to struggle with HPCs despite owning the leading computer company, Legend (BEA 1999, 77). In 1997, the PRC's University of the Science and Technology for National Defense announced it had developed a computer, the Yinhe III (or Galaxy III), capable of 10-13,000 MTOPS; however, the mass producing of HPCs and the required software is not cost effective (BEA 1999, 78).

The PRC's 2002 missile export control list omits IMU Platform Testers, which are accuracy testers for the IMU that keeps a missile on course. "The IMU platform tester, also known as a rate table, is the single most important piece of equipment for design, production, and flight testing of gyros" (Saunders 2002, 9). That the PRC is not willing to identify a piece of equipment that other governments would deny a license to export suggests it needs IMU testers to complete analysis on GPS and INS integration. In addition, the PRC's own missile export control list omits precision machines such as vibration test equipment, environmental chambers, and radiation accelerators (X-rays) that analyze missile component performance, suggesting the PRC does not want to limit itself in acquiring or sharing information on missile development (Saunders 2002, 13).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Significance of Technology Acquisition

Early in the 20th century, the Italian military strategist, General Guilio Douhet, theorized that strategic attack alone could force nations to lose their morale and will to fight. Despite the powerful effects by strategic bombers during the course of the century, Douhet's theory was never fully realized, partly because precision navigation and target identification was a primary assumption that could not be duplicated on the battlefield. The acquisition and incorporation of precision technologies and guidance systems by the PLA over the last decade, in conjunction with target saturation by ballistic and cruise missiles, may prove Douhet correct in a missile campaign against Taiwan. A comparison outlined in Table 3 demonstrates the PRC's overwhelming missile capability against U.S. and Taiwanese missile defense systems, both in theater and strategic missile campaigns. In terms of theater missile defense in a Taiwan scenario, the PRC will achieve and maintain overall missile superiority through 2010, since Chinese missile deployments opposite Taiwan have been continuing at a rate of at least fifty new missiles per year (Gertz 2002).

Both the PATRIOT and THAAD systems are likely capable enough to engage the DF-11 variant in defended asset areas, but the key lies in numbers and the DF-11 variant's mobility to launch from azimuths of varying degrees. Despite the PATRIOT Advanced Capability (PAC-3) upgrades in missiles, electronics, computers, and software, there simply are not enough systems built and crews trained to protect critical assets (such as ports, airbases, command facilities, and logistics bases) on the island of Taiwan, much less ports and bases in the Pacific Rim that could be used as staging areas for U.S. reinforcements by air and sea. Admiral Dennis Blair, outgoing commander of U.S. forces

Table 3. PRC Missile Effectiveness Against Current and Developing Missile Defenses

Missile vs. Missile Defense	DF-11 Variant SRBM	DF-31 ICBM	DF-41 ICBM	JL-2 ICBM	YJ-22 LACM
Nike-Hercules	Missile Supremacy	N/A	N/A	N/A	Missile Supremacy
PATRIOT	Missile Parity	N/A	N/A	N/A	Missile Superiority
THAAD	Missile Parity	N/A	N/A	N/A	N/A
Airborne Laser (ABL)	N/A	Missile Parity	Missile Parity	Missile Parity	N/A
Ground-Based Midcourse Defense (GMD)	N/A	Missile Parity	Missile Parity	Missile Parity	N/A
Sea-Based Midcourse Defense (SMD)	N/A	Missile Parity	Missile Parity	Missile Parity	N/A

in the Pacific, told the House Armed Services Committee that China could do “great damage” to Taiwan with the DF-11 variant, “because of China's buildup of short-range ballistic missiles, which there are only small numbers of Patriots that can intercept” (Gertz 2002).

The PLA leadership is aware of this, stating “we evidently enjoy superiority in terms of the number of short-range and middle-range missiles,” particularly as Taiwan’s own ballistic missile strike capability is limited (Central Military Commission 1999). If the DF-11 variant is successfully integrated with a kick motor, PATRIOT and THAAD systems will be challenged to rapidly respond to changes in the ballistic trajectory of a target. Taiwan's antiquated force of Nike-Hercules surface-to-air missiles (SAMs) would likely be used to counter any DF-15 missile threats, or converted as its own missile strike capability.

If succeeding in being developed, the YJ-22 cruise missile poses a considerable risk to an adversary of the PRC. Although the PATRIOT system can defend against profiles such as LACMs, the YJ-22 cruise missile would pose a significant challenge if it successfully integrates midcourse GPS and TERCOM to plot waypoints and routes to skirt or evade missile system sensors that are essentially static in position. Such an LACM could be used to avoid sensors to attack from a position or direction from which missile defenses are weakest or nonexistent.

The integration of precision technologies in the DF-11 variant best exemplifies Sun Tzu's philosophy "to avoid the full and attack the empty." By aggressively acquiring foreign missile technology, the 2nd Artillery Corps is now the arm that can influence the outcome of the Taiwan conflict to the PRC's favor without ever firing a shot. While expanding the PRC's sphere of influence in the Pacific Rim with the DF-11 variant's range, U.S. bases have become intersecting ground, in which the control and free access by the United States is in doubt.

In terms of a strategic missile defense involving ICBMs launched from the PRC, the PLA could essentially guarantee missile parity if the DF-31 can become operational. Currently, the PRC does not have a nuclear deterrent because its aging, limited silo-based force is susceptible to satellite observation and precision attack from the United States. With the production of DF-31, DF-41, and JL-2 systems, the PRC could provide a dispersed, accurate, and highly mobile counterstrike capability that would rival the former Soviet systems.

Conversely, U.S. strategic missile defenses could thwart the 2nd Artillery Corps efforts. As related to ICBMs, “the effectiveness of China’s ‘minimum deterrence’ doctrine hinges on the inability of an adversary to destroy all of China’s WMD capabilities in a first strike” (Swaine with Runyon 2002, 46). The Missile Defense Agency (MDA) has achieved successes in midcourse interceptor development, specifically with the development of an X-band radar in the ground-based midcourse defense (GMD). In addition, the navy’s sea-based midcourse defense (SMD) program achieved a degree of success on November 21, 2002, when an Aegis cruiser successfully intercepted a ballistic missile just prior to attaining apogee. However, these systems, along with the airborne laser (ABL), will likely not be ready before the DF-31 is fielded.

In order to achieve development in its ICBM programs, Beijing's response to U.S. national missile defense (NMD) planning was signaled by its October 1999 announcement of a program earmarking an additional $9.7 billion to boost its second-strike capabilities (Roberts, Manning, and Monteperto 2000, 53-63). If the DF-31 can become operational, its MIRV technology could provide a nuclear deterrence against the United States, allowing the PRC to enhance its reputation in the region with a nuclear standoff capability in case the situation in Taiwan involved the United States as an adversary. However, this capability would likely be only for a window of time in terms of years if the MDA successfully develops a midcourse intercept capability against ICBMs, thus negating MIRV technology in the terminal phase.

Because the PLA's efforts to develop MIRVs for its mobile ICBMs and LACMs will encounter costly technical hurdles, the PRC can be expected to rely heavily on foreign assistance and expertise from Russia, as cash-strapped researchers, scientists, and engineers are more susceptible to sharing information and research (NIC 2001, 10).

Recommendations on a Technology Ban

Over the next decade, a technology ban on precision technologies could have a significant affect on the PLA's developing missile programs. A ban would certainly alleviate national security concerns for the United States, but it also would have negative consequences for U.S. businesses in the PRC. Such a ban must be carefully studied before implementation, and integrated not only in international missile control lists, but with controls and regulations of the Departments of State, Commerce, and Defense, such as the Militarily Critical Technology List (MCTL) that is now managed by DOD.

The United States must prevent the acquisition of anti-GPS devices that are involved in meaconing, intrusion, jamming or interference (MIJI) of any GPS signal. The foremost precision technology that will significantly advance the PRC's missile programs is GPS. Since GPS anti-jam and anti-jamming countermeasures are beginning to be designed, produced, and--in the unsuccessful Iraqi use of Russian anti-GPS jamming equipment during Operation Iraqi Freedom--fielded, such technology must not be leaked through U.S. companies to the PRC's state-owned corporations.

The United States must deny the exploitation of technologies that design, develop and manufacture advanced materials. As the PRC will seek to enhance missile payload and missile body efficiency against atmospheric conditions, composite material machine tools (to include those involved in stealth fabric design) will be critical to improving DF-41 and YJ-22 designs while, in turn, frustrating missile defense systems.

The United States should carefully consider the PRC's true intentions when Chinese diplomats sign missile proliferation or technology bans. Based on the PRC's recent 2002 White Paper on National Defense, the PLA will continue to aggressively seek foreign technology. It is evident that the PLA's research academies share information and are adept at exploiting dual-use technologies to support the 16-Character Policy of the "civilian supporting the military." Because the PRC's acquisition policies of missile technology and the export bans of missile technology under international treaties or joint-venture agreements are in direct conflict with each other, the PLA can be expected to trump any treaty to acquire precision technologies in order to maintain its edge in land-based missile systems.

The United States should continually change and modify its export regulations and security procedures in order to prevent the PRC from exploiting exportation loopholes and security lapses. According to the Bureau of Export Administration, "technology transfer is both mandated in Chinese regulations or industrial policies (with which US companies wishing to invest in China must comply) *and* used as a deal-maker or sweetener by US firms seeking joint venture contracts in China"(BEA 199, 6). Additionally, "it is estimated that there are 11 million classified documents in the hands of U.S. Industry" (DSS *Industry Security*, 1).

The United States can expect to enhance its reputation in the region by highlighting the PRC's acquisition activities. The enforcement of limitations or bans on technology transfers will draw attention to the PRC's activities, and make it isolated in terms of its complicity and refusal to be a full member of the MTCR or even a subscribing member of the new International Code of Conduct Against Ballistic Missile Proliferation.

On the other hand, a technology ban will negatively impact U.S. businesses. In 1996, out of the top ten U.S. companies that invested in the PRC, seven companies were involved in aerospace, electronics, or computers (Motorola, United Technologies, Lucent Technologies, General Electric, General Motors, Hewlett-Packard, and IBM) (BEA 1999, 72). Certainly, a technology ban would affect U.S. corporate investments in the Pacific region, with a larger share going to the European Union. In 1999, the European Union was the largest importer of technology, representing 43.8 percent of China's total imports of technology, compared to 25.5 percent from Japan and 18.3 percent from the United States (Andreosso-O'Callahan 1999, 1).

The U.S. enforcement of export regulations and technology bans will possibly contribute to Chinese engineers, scientists, and researchers returning home. According to the Bureau of Export Administration, the PRC has no shortage of well-trained scientists, engineers, mathematicians, or other technical experts, unlike the United States, which is suffering from a lack of educated citizens in this field. More than half of the PRC's scholars working on key research projects were educated abroad over the last decade (BEA 1999, 2). Contacts and influencers will likely persuade PRC scientists studying or working in the United States to return home. According to the BEA, the "brain drain" from the PRC as a result of the Tianamen Square massacre has abated, and more Chinese students and scientists have returned home upon completion of undergraduate or graduate-level work, with the PRC actively recruiting these professionals using preferential hiring, incentives, and disincentives (such as paying back or reducing student loans) (BEA 1999, 17).

The PLA has successfully achieved a missile gap between the 2nd Artillery Corp's missile forces and U.S-Taiwanese missile defenses that will favor the PRC over the next decade. However, this study concludes that the PLA's missile development programs are not self-sustaining, and will require the acquisition of foreign, precision technologies and expertise in order to be successfully developed. The enforcement of a ban on the precision missile technologies identified in this paper will alter the PRC's apparent overall missile superiority, and will posture missile defenses to fill the emptiness that the PLA seeks to exploit with its five advanced missile programs. For if the emptiness is filled, the PLA will no longer be able to attack the empty; rather, its missile forces will have prepared for an empty attack.

REFERENCE LIST

Andreosso-O'Callaghan, Bernadette. 1999. Technology Transfer: A Mode of Collaboration between the European Union and China. *Europe-Asia Studies* (Jan 1999). Data on-line available from www.findarticles.com. Accessed 17 December 2002.

Arms Control Association. 2002. *U.S. Missile Defense Programs at a Glance*. Data on-line available from www.armscontrol.org/factsheets/usmissiledefense.asp. Internet. Accessed 02 January 2003.

Arms Control Association. 2002. *World Ballistic Missile Inventories*. Data on-line available from www.armscontrol.org/factsheet. Internet. Accessed 03 January 2003.

Bureau of Industry and Security. *Frequently Asked Questions about the Missile Technology Controls*. Data on-line available from the BIS website, US Department of Commerce. Internet. Accessed 10 November 2002.

Bureau of Export Administration. 1999. *U.S. Commercial Technology Transfers to the People's Republic of China*. Data on-line available from www.fas.org/nuke/guide/china/doctrine/China2.pdf. Accessed 11 December 2002.

C-Span. 1999. *Report on Chinese Espionage*. Data on-line available from www.christus-rex.org/www2/china/Manufacturing. Internet. Accessed 12 September 2002.

Center for Nonproliferation Studies. *Chinese Export Controls and Jiang Zemin's Visit to the United States.* Data on-line available from cns.miis.edu/research/china/chiexp/index.htm. Internet. Accessed 11 November 2002.

Central Intelligence Agency. 2002. *Questions for the Record on the Worldwide Threat Hearing 6 February 2002*. Data on-line available from www.fas.org/irp/congress/2002_hr/020602cia.html. Internet. Accessed 14 November 2002.

Central Intelligence Agency. 2001. *Unclassified Report to Congress on the Acquisition of Technology Relating to Weapons of Mass Destruction and Advanced Conventional Munitions, 1 January thru 30 June 2001*. Data on-line available from www.cia.gov/cia/publications/bian/bian_jan_2002.htm#13. Internet. Accessed 28 August 2002.

Central Intelligence Agency. 2001. *Unclassified Report to Congress on the Acquisition of Technology Relating to Weapons of Mass Destruction and Advanced Conventional Munitions, 1 July thru 31 December 2001*. Data on-line available from www.cia.gov/cia/publications/bian/bian_jan_2003.htm. Internet. Accessed 17 January 2003.

Department of Arms Control and Disarmament, Chinese Foreign Ministry. 2002 *Regulations of the People's Republic of China on Export Control of Missiles and Missile-related Items and Techologies.* Data on-line available from www. nti.org/db/china/prcdocs.htm#Law. Internet. Accessed 23 September 2002.

Department of Defense. 2001. *Joint Pub 1-02, Department of Defense Dictionary of Military and Associated Terms.* Wash. D.C.: US Government Printing Office.

Department of Defense. 2001. *Joint Pub 3-01*, *Joint Doctrine for Countering Air and Missile Threats.* Wash D.C.: US Government Printing Office.

Defense Security Service. *Industrial Security*. Data on-line available from www.dss.mil /isec/index.htm. Accessed 25 November 2002.

Dorminey, Bruce. 1999. Chinese Missile Basic to New Strategy. *Aviation Week and Space Technology*. 08 March 1999.

Federation of American Scientists. *China Nuclear Forces.* Data on-line available from the FAS website, www.fas.org/nuke/guide/china. Internet. Accessed 11 December 2002.

Gill, Bates, and Mulvenon, James. 1999. China and Weapons of Mass Destruction: Implications for the United States. Data on-line available from the National Intelligence Council website, ww.cia.gov/nic/pubs/conference_reports/weapons_ mass_ destruction.html. Internet. Accessed 17 January 2003.

Gertz, Bill. China Assembles Missiles near Coast facing Taiwan. *The Washington Times.* Data on-line available from www.washtimes.com/national/20020402-960421.htm. Internet. Accessed 18 December 2002.

Gertz, Bill. Missile-related Technology Sold to Beijing by Belarus. *The Washington Times*, 12 June 1997: 9.

Gertz, Bill. Notes from the Pentagon. *The Washington Times.* Data on-line available from www.gertzfile.com/gertzfile/ring040601.html. Internet. Accessed 02 September 2002.

Global Secruity. *Chinese Missiles.* Data on-line available from www.globalsecurity.org/ Military/world/china/c-802.htm. Internet. Accessed 02 January 2003.

Information Office of the State Council Of the People's Republic of China. 2000. China's National Defense in 2000. Data on-line available from www.fas.org/nuke/guide/ china/doctrine. Internet. Accessed 11 December 2002.

Information Office of the State Council Of the People's Republic of China. 2002. China's National Defense in 2002. Data on-line available from www.fas.org/nuke/guide/china/doctrine. Internet. Accessed 14 January 2003.

Colonel Liang, Qiao, and Colonel Xiangsui, Wang. 2002. *Unrestricted Warfare: China's Master Plan to Destroy America*, with an introduction by Al Santoli. Panama City, Panama: Pan American Publishing Company.

Liao, Holmes S. 2000. *China's Military Technology Modernization.* Division of Strategic and International Studies. Taiwan: Taiwan Research Institute.

Missile Technology Control Regime. 1998. *Missile Technology Control Regime Annex Handbook.* Data on-line available from www.fas.org. Internet. Accessed 19 October 2002.

Murton, Mark D. 1991. *Trip Report, 1991 Air Defense Artillery Conference.* Department of Military Instruction. West Point: United States Military Academy.

National Intelligence Council. 2001. *Foreign Missile Developments and the Ballistic Missile Threat Through 2015.* Data on-line available from www.cia.gov/nic/pubs. Internet. Accessed 11 December 2002.

New Taiwan. *Chronology of Recent Events in US-Taiwan and US-China Relations*. Data on-line available from www.taiwandc.org/hst-9596.htm. Internet. Accessed 03 September 2002.

Nuclear Threat Initiative. *Chinese Missile Imports and Assistance from Abroad.* Data on-line available from www.nti.org/db/china/mimport.htm. Internet. Accessed 12 September 2002.

Nuclear Threat Initiative. *China Profiles Database.* Data on-line available from www.nti.org/db/china/wdsmdat.htm#BALLISTIC%20MISSILES. Internet. Accessed 17 December 2002.

Nuclear Threat Initiative. *Nuclear System Delivery Modernization.* Data on-line available from www.nti.org/db/china/wdsmdat.htm. Internet. Accessed 25 Oct 2002.

Office of the Central Military Commission of the Communist Party of China. 1999. *Watching Closely for Changes in the Relationships with Taiwan and Enhancing the Awareness by Military Leadership of the Current Situation*. Data on-line available from http://www.softwar.net/ocmc.html. Internet. Accessed 11 December 2002.

Roberts, Brad, Manning, Robert A., and Monteperto, Ronald N. 2000. China: The

Forgotten Nuclear Power. *Foreign Affairs* 79 (July/August 2000): 53-63.

Saunders, Phillip C. 2002. *Preliminary Analysis of Chinese Missile Technology Export Control List.* Data on-line available from cns.miis.edu/research. Internet. Accessed 23 September 2002.

Scobell, Andrew. 1999. *Show of Force:The PLA and the 1995-1996 Taiwan Strait Crisis.* Stanford, CA: Asia/Pacific Research Center, Stanford University. Data on-line available from aparc.stanford.edu/docs. Internet. Accessed 08 November 2002.

SpaceandTech.com. *Space and Tech.com Digest.* Data on-line available from www. spaceandtech.com/digest/flash-articles/flash2000-082.shtml. Internet. Accessed 13 January 2003.

Softwar. *Dong Feng/Julang Series Missiles.* Data on-line available from www.softwar.net/dongfeng.html. Internet. Accessed 11 December 2002.

Softwar. *MARV Deployment.* Data on-line available from www.softwar.net/missile.html. Internet. Accessed 02 January 2003.

Sun Tzu. 1988. *The Art of War.* Translated by Thomas Cleary. Boston: Shambhala Publications.

Swaine, Michael D., and Runyon, Lorel H. 2002. Ballistic Missiles and Missile Defense in Asia. *National Bureau of Asian Research Analysis* Volume 13, Number 3 (June 2002): 1-84.

Strategic Defense Initiative Organization. 1992. *Ballistic Missile Proliferation: An Emerging Threat 1992.* Arlington, VA: System Planning Corporation.

U.S. Congress. House. *Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China* [declassified version]. 1999. Report submitted by Christopher R. Cox, Chairman. 105th Congress, 2d sesssion, Report No. 105-851. Washington, D.C.: Government Printing Office.

Varner, Joe. 1999. "China's Superpower Challenge." Paper delivered at the Second Graduate Student Symposium, 13-13 November 1999. Conference of Defence Associations Institute. Data on-line available from http://www.cdacdai.ca/symposia/1999/varner99.htm. Internet. Accessed 03 January 2003.

Virtual Information Center. 2000. *Special Report: China's Defense Budget and Arms Procurement Priorities.* Data on-line available from http://www.vic-info.org/regionstop.nsf. Internet. Accessed 02 January 2003.

Virtual Information Center. 2001. *Special Report: China's Strategic Nuclear Force*. Data on-line available from http://www.fas.org/nuke/guide/china. Internet. Accessed 26 August 2002.

Yuan, Jing-Dong. 2002. Beijing's Nonproliferation Record. *Far Eastern Economic Review*, 03 October, The Fifth Column. Availabe from www.feer.com. Internet. Accessed 05 October 2002.

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