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Ballistic Missiles and Missile Defense in Asia

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Foreword

The proliferation of ballistic missiles and related technologies in Asia is a growing concern, both within the region and for the United States. Despite the May 2002 historic agreement between Russia and the United States to reshape the global strategic environment by slashing the numbers of deployed nuclear warheads and proceeding with plans for missile defense systems, U.S. policymakers must continue to pay close attention to activities and mechanisms that will prevent proliferation of ballistic missiles. Asia provides striking examples of the complex interactions between ballistic missile development programs, plans for missile defense systems, and the proliferation of missiles and weapons of mass destruction within and beyond the region. The development of these capabilities has increased the severity of the threats that exist in several potential flashpoints within the region—between India and Pakistan, China and Taiwan, and North and South Korea (and Japan)—as well as to forward-deployed U.S. forces in Asia and even to the United States itself. Moves to counter this threat with missile defense, and the possible development and deployment of theater missile defense capabilities by U.S. friends and allies, have the potential to improve the security environment by reducing the attractiveness of ballistic missiles, or to challenge it by prompting some states to accelerate their missile programs in an attempt to overcome such defensive systems.

In this issue of the *NBR Analysis*, Dr. Michael D. Swaine, senior associate and codirector of the China Program at the Carnegie Endowment for International Peace, with assistance from Loren H. Runyon, senior intern at NBR, outlines the ballistic missile capabilities and development programs of various Asian states. He examines the role of ballistic missiles in each state's force structure, strategy, and doctrine, and considers the reactions of each to proposals for U.S. national missile defense and possible regional theater missile defense systems. Dr. Swaine concludes that these developments have significant implications for the Asian security environment and for U.S. political and military interests over the course of the next decade.

Dr. Swaine begins with a detailed examination of the ballistic missile holdings and development programs of the thirteen Asian states that already possess such capabilities (or, as in the case of Japan, that are able to develop such capabilities relatively quickly). Of particular concern are China's deployment of greater numbers of short-range missiles across the strait from Taiwan, which, he argues, might increase Beijing's willingness to use force in a crisis over the island, and the ability of Pyongyang to strike targets in Japan in the event of renewed hostilities on the Korean Peninsula—a capability it did not possess during the 1950–53 Korean War. Moreover, the rapid development of ballistic missiles and WMD in both India and Pakistan has greatly increased the risk of a dangerous escalation of any conflict between the South Asian neighbors. Dr. Swaine then assesses ballistic missile transfers among and from Asian states, highlighting the role that countries like China, North Korea, and to a lesser extent Pakistan (and India) have or are likely to play. He warns that proliferation of missiles and related technologies might increase the likelihood that additional states, and also non-state actors such as terrorists, will acquire ballistic missile and WMD capabilities.

Dr. Swaine concludes with an examination of the probable reactions of various Asian states to ballistic missile defense efforts that are currently under research and development. Although such systems may reduce the vulnerabilities and threats arising from ballistic missiles, and even reduce incentives to deploy or proliferate missiles, he argues that missile defense systems are as likely to complicate or exacerbate the threat posed by ballistic missiles—as potential adversaries might attempt to overwhelm missile defense systems through expansion of their missile development programs, or to neutralize missile defense by launching pre-emptive strikes before such systems are fully in place. He urges U.S. policymakers to consider carefully the impact of the planned U.S. national missile defense system on the security environment in Asia.

Dr. Swaine's paper—a shorter and earlier version of which was published as a chapter in *Strategic Asia 2001–02: Power and Purpose*—adds new dimensions to themes addressed in previous issues of the *NBR Analysis*, such as Ashley Tellis's "India's Emerging Nuclear Doctrine" (May 2001) and Michael Green and Toby Dalton's "Asian Reactions to U.S. Missile Defense" (November 2000) by further explicating and assessing the development of ballistic missiles and WMD in Asia.

We are very grateful to the Center for Nonproliferation Studies at the Monterey Institute of International Studies and the U.S. Department of Energy for supporting this study, and to the Henry M. Jackson Foundation for its support to The National Bureau of Asian Research. As with all NBR reports, the author is solely responsible for the content and recommendations of this paper.

Richard J. Ellings
President
The National Bureau of Asian Research

Ballistic Missiles and Missile Defense in Asia

Michael D. Swaine with Loren H. Runyon

The significance of ballistic missiles to U.S. national security cannot be overlooked in the wake of the September 11 terrorist attacks. Although ballistic missiles may not be the cheapest or most covert weapon a state (or a non-state actor) could deploy against the United States, ballistic missiles arguably are the highest profile delivery system for weapons of mass destruction (WMD). The dramatic spread of ballistic missile technology in the Asia Pacific over the past two decades underscores the serious threat that ballistic missiles pose to the security and stability of the region, to U.S. forward-deployed forces there, and even to the United States itself. The development of ballistic missile capabilities and the proliferation of missiles and missile-related technologies in the region over the next 10–15 years will be concentrated in Northeast Asia and South Asia. China, North Korea, and Pakistan likely will be the states most involved in transfers of missiles and related technologies. The expansion of missile capabilities, and U.S. ballistic missile defense (BMD) plans, have stimulated interest in the region in the development and deployment of possible defensive countermeasures, most notably in Japan and Taiwan. The development of robust (i.e. including both lower-tier and upper-tier) BMD systems could have potentially destabilizing effects across Asia. Such measures would alter significantly the perceived strategic balance in the region, and could contribute to increased tension in three major potential flashpoints: the Taiwan Strait, Northeast Asia (both the Korean Peninsula and between Korea and Japan), and in South Asia. These developments underscore the need for the United States to carefully examine the implications for U.S. security interests of ballistic missile developments in Asia, including missile defense.

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Introduction

An unclassified National Intelligence Council report released on January 9, 2002, noted that the United States is likely to face long-range ballistic missile threats from North Korea and Iran, in addition to China and Russia, by 2015. It also argued that short- and medium-range ballistic missiles already pose a threat to U.S. interests, military forces, and allies in Asia.[1] The development of ballistic missile capabilities, and the proliferation of missiles and missile-related technologies, are an increasingly significant security concern for the United States and many Asian countries. Ballistic missiles are of particular concern because, when armed with conventional high explosive warheads, or especially nuclear, chemical, or biological warheads, they present a combination of capabilities and features unmatched by any other weapon.[2] Such missiles can travel at supersonic speeds, reducing warning time in some cases to a few minutes. They can cover enormous distances, in some cases over 10,000 km, potentially threatening the rear areas of a military theater or even the homeland of an opponent. In many cases missiles can strike a target with a high level of accuracy and with enormous force, often producing devastating damage before an opponent can react. Since ballistic missiles are unmanned, their use does not risk the loss of highly skilled military personnel such as pilots. Furthermore, a missile will not defect or refuse to carry out orders. In addition, ballistic missiles are very difficult to defend against, especially if a potential opponent desires to intercept them before they can strike their intended targets.[3] And unlike airfields or artillery bases, which are large, fixed, vulnerable targets prone to attack, hidden or mobile missiles are hard to find and destroy. Finally, many types of missiles are relatively easy to deploy and operate, especially compared to a trained air force with manned aircraft and a large infrastructure.

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[1] National Intelligence Council, *Foreign Missile Developments and the Ballistic Missile Threat through 2015*, January 9, 2002.

[2] A ballistic missile is rocket-powered during the boost phase of its flight and then travels by its own momentum in or above the atmosphere before it falls to its target with the aid of a guidance system. Ballistic missiles are typically classified by a number of capabilities and characteristics, the first being range: 1) battlefield short range (BSRBM), capable of traveling up to 150 km; 2) short range (SRBM), from 150 km to 1,000 km; 3) medium range (MRBM), from 1,000 km to 3,000 km; 4) intermediate range (IRBM), from 3,000 km to 5,500 km; and 5) intercontinental (ICBM), which can reach targets more than 5,500 km away. See Appendix for additional information on the types and components of ballistic missiles.

[3] "Whether short or long range, a successfully launched ballistic missile has a high probability of delivering its payload to its target compared to other means of delivery," *Report of the Commission to Assess the Ballistic Missile Threat to the United States*, July 15, 1998 (hereafter the Rumsfeld Report).

Whether used as operational weapons of war or as strategic weapons of deterrence or coercive diplomacy, the development, deployment, and transfer of ballistic missiles pose several concerns for both Asian and U.S. leaders. First, ballistic missiles can increase the sense of vulnerability of key states—including U.S. friends and allies in the Asia Pacific region—and thus raise tensions and undermine stability. A potential aggressor with a significant ballistic missile arsenal might be tempted to resort to greater political or military threats, or to lower the threshold at which it might use force in a crisis. Such a possibility might, in turn, prompt a variety of military and political responses from other states that could increase tensions further, perhaps undermining key political relationships, raising the likelihood of conflict, and diverting resources away from economic growth. In addition, such missile-induced tensions might compel the United States to strengthen the security assurances it provides to its allies and friends in the region, potentially increasing the overall political costs of the U.S. regional presence.

Second, ballistic missiles could increase the direct threat posed to U.S. forward-deployed forces in Asia. Such a threat has many implications, including raising significantly the cost of protecting U.S. bases and forces. More broadly, a growing ballistic missile threat to U.S. regional forces could provoke debates in the United States over the size, scope, and utility of America's forward-deployed military presence in the region. Perhaps most ominously, ballistic missiles could also complicate decisions on when, how, and where to deploy U.S. forces in a crisis. Indeed, the possession of ballistic missiles tipped with weapons of mass destruction (WMD) by a potential adversary could, under certain conditions, deter the United States, thereby damaging U.S. credibility and increasing the risk of instability and conflict. Finally, fears of possible ballistic missile attacks against U.S. bases could lead host countries to curtail U.S. military access or modify the conditions under which U.S. forces could be deployed in the region, thus aggravating relations with Washington.

Third, the growing presence of ballistic missiles in Asia could stimulate the proliferation of entire missiles, missile components, missile-related technologies, and WMD warheads, both within the region and beyond. Such a development could accelerate the pace of ballistic missile growth within Asia, destabilize regions beyond Asia, and increase the possibility that terrorists would use ballistic missiles against the United States or its allies and friends.

Fourth, the possession of intermediate or long-range ballistic missiles by Asian states hostile to U.S. interests could greatly increase the ability of such countries to directly threaten U.S.

territory. Such a threat would exert a much greater impact on U.S. decision-making during a crisis than missile threats to U.S. forces in the region. It could also influence U.S. calculations regarding the development of theater and national missile defense (TMD and NMD) systems.

The dangers and concerns presented by the development, deployment, and transfer of ballistic missiles in Asia have prompted the United States and some Asian countries to consider a range of measures to defend against such weapons, including ballistic missile defense (BMD) systems of various types. These systems might serve to reduce the potential for greater missile-induced political instability in the region by lowering vulnerabilities and threats, as well as by avoiding possible future tensions between the United States and its allies and friends in the region. Equally important, BMD might also reduce incentives to proliferate or deploy ballistic missiles; decrease the attractiveness of missiles to terrorists and other non-state actors[4]; and perhaps support the U.S. effort to deploy a national missile defense system. Conversely, missile defense systems might on balance complicate and even worsen the threat posed by ballistic missiles in Asia. In particular, some states—including potential U.S. adversaries—might attempt to overwhelm or neutralize missile defense systems by deploying more missiles, adding multiple warheads, or utilizing decoys and other countermeasures. Such efforts could generate an offensive-defensive arms race that might ultimately heighten political tensions and instability in the region, increase the likelihood of conflict by tempting preemptive actions or lowering the threshold for the use of force in crisis, and divert resources away from civilian uses.

As the above suggests, the growing presence of ballistic missiles in Asia arguably constitutes one of the most significant and complex factors influencing the regional security environment. This study identifies and analyzes the major features of ballistic missile development and ballistic missile defense, and attempts to assess their possible implications for regional security and U.S. interests. The study begins with an examination of the current situation, major trends, and possible future trajectories in ballistic missile development for every country in Asia that currently possesses and/or is developing ballistic missiles. This is followed by an assessment of the current and possible future status of ballistic missile transfers among, into, or out of Asian states, and a subsequent analysis of the role that ballistic missiles play in the force structure,

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[4] However, following the September 11 attacks on the World Trade Center and the Pentagon, the U.S. intelligence community judged that the United States is more likely to be attacked with WMD through non-missile means than with ballistic missiles. NIC, *Foreign Missile Developments*, p. 15.

strategy, and doctrine of the most important Asian countries. These sections are followed by an examination of the status of BMD efforts in Asia, including the attitude of key countries toward missile defense and the direction of BMD efforts underway. The study concludes with an assessment of the implications of the analysis for the Asian security environment and U.S. interests, both at present and in the future.

Ballistic Missile Holdings and Development Programs[5]

Of the 34 countries worldwide possessing some type of ballistic missile, almost one-third are located partly or entirely in Asia: Afghanistan, China, India, Kazakhstan, North Korea, Pakistan, Russia, South Korea, Taiwan, the United States, and Vietnam.[6] Another Asian country, Japan, does not currently possess ballistic missiles but could develop them in a short period of time. This study focuses primarily on seven of these 12 countries: China, India, Japan, North Korea, Pakistan, South Korea, and Taiwan. Three of the remaining five countries—Afghanistan, Kazakhstan, and Vietnam—possess only a small number of short-range ballistic missiles (SRBMs) originally purchased from the Soviet Union or Russia. Because of

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[5] All missile data have been complied from several sources, some of which are generally regarded as more accurate than others. Missile numbers are primarily taken from various editions of the International Institute for Strategic Studies' *The Military Balance*, Oxford University Press. The Carnegie Endowment for International Peace's Nonproliferation Project website <www.ceip.org/files/projects/npp/resources/ballisticmissilechart.htm> was used for missile numbers, ranges, and payload data. The Federation of American Scientists' website <www.fas.org/news/index.html> was used for technical data, missile numbers, and test history. The Center for Defense and International Security Studies website <www.cdiss.org/tempor1.htm> was used primarily for range and payload data, as well as some technical data. The Canadian Security Intelligence Service website <www.csis-scrs.gc.ca/eng/miscdocs/200009_e.html> was also referenced. Among these sources, CEP (circular error probability) figures were the most divergent statistics. CEP calculations are generally extrapolations based on the tracking of test flights (which are often short of the missile's full capabilities); differences may also arise from the presence or absence of terminal guidance upgrades and strap-on navigation systems. Range and payload estimates can also vary significantly. This is not only because of ambiguity regarding a particular missile's statistics, but also due to the range-payload tradeoff. Missiles that have been licensed, re-engineered, or improved may have lightened payloads in order to increase range; in some cases this is due to attempts to avoid counter-proliferation measures such as the Missile Technology Control Regime (MCTR).

[6] Center for Defense and International Security Studies <www.cdiss.org> and the Carnegie Endowment's nonproliferation website <www.ceip.org/files/projects/npp/resources/ballisticmissilechart.htm>.

their short range and deployment locations, these missiles are of little significance to the regional security environment and thus are not discussed in this study.[7] Conversely, the ballistic missile and missile defense programs of the United States and Russia hold relevance for broad strategic and political issues extending well beyond Asia. Hence, these programs are discussed only as part of the analysis of other states located entirely in Asia. Among the aforementioned seven Asian states examined in this study, only China currently possesses a full array of ballistic missiles, from battlefield short-range ballistic missiles (BSRBMs) to long-range intercontinental ballistic missiles (ICBMs). India, Pakistan, and North Korea possess much smaller missile arsenals, in both size and diversity of range, although all three are endeavoring to remedy these shortcomings to varying degrees. South Korea and Taiwan possess only relatively modest inventories of BSRBMs and SRBMs but are engaged in notable programs of research and development. More important, these two states possess enormous political or strategic significance for the larger Asian security environment.

The pace of ballistic missile development in Asia (including the introduction of new systems and the expansion of existing systems) could accelerate notably over the next 10 to 15 years, although virtually all of this activity will almost certainly occur in a relatively small number of countries. As indicated below, several Asian states are in the midst of a long-term effort to augment their existing missile inventories. Moreover, a larger number of states have active missile research and development programs underway. Most, if not all, of these programs will likely yield results within the next 10–15 years. However, any assessment of future ballistic missile development trends by necessity requires a considerable amount of informed speculation, given the number and complexity of variables involved. In particular, four major complicating factors will greatly influence the future direction and configuration of ballistic missile development in Asia.

First and foremost is the state of political and military relations among key states, including: 1) globally and regionally among China, the United States, and Russia; 2) on the Korean Peninsula—among North and South Korea, the United States, and Japan; 3) in Northeast Asia more broadly, between the United States, China, Taiwan, and Japan; and 4) in South Asia, among India, Pakistan, and China. Second, the internal political and economic environment within key Asian countries that produce and/or transfer ballistic missiles or missile-related items—such as the United States, Russia, China, North Korea, India, and Pakistan—

[7] It is possible that Afghanistan's small arsenal of SRBMs has been destroyed or seized by the U.S.-led coalition forces that were deployed following the September 11 attacks.

Table 1. Ballistic Missile Arsenals and Development Programs

Country	Type	Nomenclature	Number
Afghanistan	SRBM	Scud-B	unknown
China	SRBM	Dongfeng-11, 11A	40
	SRBM	Dongfeng-15	150–200
	BSRBM	M-7	unknown
	MRBM	Dongfeng-21, -21A	8–50
	MRBM	Dongfeng-3, -3A	80–100
	IRBM	Dongfeng-4	10–30
	ICBM	Dongfeng-5, -5A	7–20
	ICBM	* Dongfeng-31	under development
	ICBM	* Dongfeng-41	under development
	SLBM	Julang-1	12
	SLBM	* Julang-2	under development
India	SRBM	Prithvi-1	12–75
	SRBM	* Prithvi-2	under development
	SRBM	* Prithvi-3	under development
	IRBM	* Agni-2	unknown
	IRBM	* Agni-3	under development
	ICBM	* Surya	under development
Kazakhstan	SRBM	Tochka-U	unknown
	SRBM	Scud-B	unknown
North Korea	SRBM	Scud-B, -C	500
	MRBM	Nodong-1	100+
	MRBM	* Nodong-2	under development
	MRBM	* Taepodong-1	under development
	IRBM	* Taepodong-2	under development
Pakistan	SRBM	Hatf-1, -1A	80
	SRBM	M-11	30
	SRBM	Hatf-2 (Abdali)	unknown
	SRBM	Hatf-3 (Shaheen or Ghaznavi)	unknown
	SRBM	Shaheen-1	unknown
	MRBM	* Shaheen-2	under development
	MRBM	Ghauri-1	12+
	MRBM	* Ghauri-2	under development
South Korea	SRBM	NHK-1, -2	12
	SRBM	* Hyon Mu	under development
Taiwan	SRBM	Ching Feng	unknown
	MRBM	* Tien Ma	under development
Vietnam	SRBM	Scud-B	unknown

Sources: International Institute for Strategic Studies, *The Military Balance 2000–2001* (Oxford: Oxford University Press, 2001); Federation of American Scientists <www.fas.org>; Carnegie Endowment for International Peace <www.ceip.org>; Center for Nonproliferation Studies <http://cns.miis.edu>; Center for Defense and International Strategic Studies <www.cdiss.org>.

could alter proliferation patterns.[8] Third, the pace and direction of theater and/or national missile defense development programs underway in the United States, and to a lesser extent in Japan, Taiwan, and perhaps China and Russia, could have an effect on other countries' ballistic missile programs. For example, technological or political breakthroughs or shifts leading to more rapid or extensive deployments of BMD systems in Asia and in the continental United States could significantly alter the trajectory of China's ballistic missile development program. A fourth consideration is shifts in bilateral cooperation, such as changes in the level and type of foreign assistance provided to Asian countries that currently possess or wish to possess ballistic missiles. For example, Iraq, Iran, Russia, North Korea, or China could accelerate and/or initiate policies to transfer missile-related items or technology to Asian states. All of these factors could intersect in various ways over the long-term to influence the evolution of ballistic missile development programs. Thus, the assessment of future trajectories contained in the following country-based discussion of ballistic missile holdings and development programs should be regarded as merely plausible, not predictive.

More rapid or extensive deployments of BMD systems in Asia and in the United States could significantly alter the trajectory of China's ballistic missile development program.

China

The CSS-4/DF-5/DF-5A is China's only true ICBM. It can deliver a very powerful nuclear warhead to any part of Russia, Europe, or the continental United States. Development began in 1965 as the 12,000 km range DF-5, but the missile did not undergo a full-range test flight until 1980 and was not deployed until 1981. The DF-5A was deployed in 1986 as a more advanced version of the DF-5. It is a two-stage missile that uses storable liquid fuel and a gyroplatform inertial guidance system with on-board computers, and has a range of approximately 13,000 km. The missile is deployed in hardened underground silos and cave entrances. The exact number of deployed DF-5/5As is not known, but most experts believe the current total is between 7 and 20. The deployed missiles are unfueled and not mated with their war-

[8] Political liberalization in China, for example, combined with continued high economic growth rates and the emergence of a new generation of Chinese and Taiwanese leaders more supportive of cross-Strait reconciliation, could significantly alter calculations about ballistic missile development in both China and Taiwan. Conversely, the continued economic decline of North Korea, combined with an increase in tensions between Pyongyang, Washington, and Seoul, could accelerate North Korea's ballistic missile development and its transfers of missile-related items.

heads, which increases their estimated preparation time to 30–60 minutes.[9] The civilian version of the DF-5/5A is known as the Long March 2C (LM-2C, or by the Chinese designation Chang Zheng 2C, CZ-2C). This launcher has been used heavily by the Chinese space program since 1975, five years before the ICBM version was completed. Given a reported yearly production of five or six CZ-2C, there might be stores of reserve DF-5/5As not deployed.[10]

The CSS-3/DF-4 was China's first two-stage rocket (using the DF-3 as the first stage) and required a variety of technical breakthroughs (e.g., engine reliability, more heat-resistant materials, and improved guidance systems). The missile is a liquid-fueled IRBM and employs a strap-down inertial guidance system. The DF-4 was originally designed with a range of up to 4,000 km and was intended to target the U.S. B-52 air base on Guam. Its range was subsequently raised to 4,500 km (and eventually attained a 5,500 km range) in order to reach Moscow and other cities in the western regions of the Soviet Union. China formally authorized development of the missile in May 1965; it was deployed in 1980. The missiles are land-mobile but are based in caves, mountainside tunnels, or underground silos and are designed to be rolled out from their tunnels to their launch pads, fueled, and fired. There are also reportedly launch sites designed for the DF-4 at several test locations. These could be used to fire any reserve missiles. The DF-4 has a response time of approximately 60–90 minutes. The exact number of missiles in the Chinese inventory is unknown, but it is estimated that between 10 and 30 are deployed at present. The civilian counterpart to the DF-4 is the Long March 1 (LM-1), which was used for the first successful Chinese satellite launch in 1970.[11]

The CSS-2/DF-3/DF-3A was the first truly indigenous Chinese ballistic missile. It is a single-stage, liquid-fueled, transportable MRBM (with a strap-down inertial guidance system) launched from a presurveyed, above-ground launch site or portable launch site. It reportedly carries a single warhead with an estimated yield of one to three megatons, but some reports suggest the DF-3A has been modified to carry three 50–100 kiloton nuclear warhead multiple reentry vehicles (MRVs).[12] The original version of this missile (the DF-3) had a range of approximately 2,650 km and was probably intended, when first conceived in the early 1960s,

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[9] Shirley A. Kan, "China: Ballistic and Cruise Missiles," *Congressional Research Service, 97-391-F*, August 10, 2000, Washington, DC, pp. 8–9.

[10] Center for Defense Information website <www.cdi.org/issues/nukef&f/database/chnukes.html>.

[11] Kan, "China: Ballistic and Cruise Missiles," p. 8; Bates Gill and James Mulvenon, "China and Weapons of Mass Destruction: Implications for the United States," National Intelligence Council website <http://www.cia.gov/nic/pubs>, November 1999; and Center for Defense Information <www.cdi.org>, especially the China nuclear arsenal database at <www.cdi.org/issues/nukef&f/database/chnukes.html>.

[12] Federation of American Scientists <www.fas.org>. See Appendix for additional information about MRV technology.

to target U.S. military bases in the Philippines. However, the missiles were apparently retargeted at Soviet population centers in the central and eastern Soviet Union after the Sino-Soviet border clashes of 1969. The DF-3 was first deployed in 1971 in caves and valleys to increase its survivability. The DF-3A (tested in December 1985 and January 1986 and deployed since 1988) has similar characteristics to the DF-3 but a slightly longer range of up to 3,000 km. The missile has also been tested with a depressed trajectory for a shorter range of 1,550 km at an altitude of 100 km, a useful capability to overcome missile defenses. The DF-3A has an estimated response time (preparation for launch after warning) of two to three hours. The missiles are currently based in northwestern, northeastern, and southern China and can target Russia, Japan, South Korea, and India. About 40 launchers for this missile are currently in evidence. The DF-3A has been described as the backbone of the Chinese missile force, with perhaps as many as 80 to 100 missiles deployed in the 1980s.[13] However, the missile is gradually being replaced by the solid-fueled DF-21s (see below), and will probably be removed from service within one to two years.[14]

The CSS-5/DF-21 is a two-stage MRBM with a range of up to 2,000 km. It is the land-based version of the Julang-1 SLBM, China's first solid-fueled ballistic missile.[15] Launched from a transporter-erector-launcher (TEL), it is also the first truly road-mobile Chinese missile. The missile uses a cold launch technique similar to that used on China's submarine launched missiles, where it is ejected from its container, and the engine ignites while airborne. The exact number of DF-21s is unknown, but estimates of deployed missiles range from as few as 8 to as many as 50, while the number of launchers might total 50.[16] Development began in 1967, the missile had its first successful test in 1985, and was reportedly deployed in 1991. It is gradually replacing the aging DF-3A. The missile reportedly contains China's first automatic command-and-control firing system and has a gyroplatform inertial guidance with an onboard computer. Likely targets for the DF-21 include urban areas in Russia and India, and perhaps Japan and Taiwan.

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[13] About 80 of the 100 DF-3s are DF-3As. Federation of American Scientists <www.fas.org>.

[14] Gill and Mulvenon, "China and Weapons of Mass Destruction"; Kan, "China: Ballistic and Cruise Missiles," pp. 7–8; and Center for Defense Information <www.cdi.org>.

[15] A solid-fueled missile is a significant improvement over the storable liquid-fueled missiles, which require more maintenance, longer preparation time, and are less stable during transatmospheric flight. Due to disruptions during the Cultural Revolution, China did not begin serious work on the solid-fuel missile program until 1978. These systems finally became fully operational in the early 1990s. See Gill and Mulvenon, "China and Weapons of Mass Destruction."

[16] Gill and Mulvenon, "China and Weapons of Mass Destruction"; Kan, "China: Ballistic and Cruise Missiles," p. 5; and Center for Defense Information <www.cdi.org>.

With poor circular error probability (CEP), the original DF-21 was equipped for nuclear missions only. However, a terminal guidance system—possibly radar-based—is apparently under development for the missile. This could permit highly accurate conventional strikes. In fact, a high explosive conventional warhead version of the DF-21, the DF-21A (CSS-5 Mod 2), reportedly exists and might already be deployed. If so, it will most likely take on a conventional role originally intended for the abandoned DF-25 program.[17]

The CSS-6/DF-15/M-9 is a single-stage, solid-fueled, mobile, 600 km range SRBM originally developed for export, as indicated by the M-designation. These missiles were not incorporated into the Chinese inventory until China pledged not to export them. The DF-15 has been deployed since 1995. It is launched from a truck-pulled trailer with a preparation time of 30 minutes and has a strap-down inertial guidance system with an on-board computer. A miniature propulsion system on the warhead can correct the missile's terminal velocity, reentry attitude, flight trajectory, and range. This control significantly improves the DF-15's accuracy and penetration and would likely complicate missile defense radar tracking, computations, and interception.[18] The DF-15 has a detachable warhead, thus presenting a much smaller target than more primitive SRBMs, such as the Scud missiles produced by North Korea. Moreover, GPS technology has probably been employed to further improve its accuracy. Although the missile has been publicized with a CEP of 300 meters, it is probably much more precise, with an actual accuracy of perhaps 50 meters or less. Originally designed to deliver conventional explosives, the DF-15 is probably also nuclear-capable.[19] To diversify China's theater ballistic missile inventory, a longer-range (1,200 km) conventional version of the DF-15 is reportedly under development. This range would permit a faster reentry speed to counter lower-tier missile defense systems and enable the missile to be fired at Taiwan from a greater distance.[20]

A new version of the DF-15 missile would enable China to fire at Taiwan from a greater distance.

[17] The DF-25 was conceived as a two-stage, land-mobile, solid-fueled missile with a 2,000 kg payload likely intended to deliver a large conventional warhead to a distance of 1,700 km using an inertial guidance system. The missile was probably intended as a tactical weapon for use in the South China Sea dispute over the Spratly Islands. There were no reports of any test firings of the DF-25 before its cancellation. Kan, "China: Ballistic and Cruise Missiles," p. 10.

[18] Mark A. Stokes, "Weapons of Precise Destruction: PLA Space and Theater Missile Development," National Intelligence Council website <www.cia.gov/nic/pubs>, November 1999.

[19] Gill and Mulvenon, "China and Weapons of Mass Destruction"; Kan, "China: Ballistic and Cruise Missiles," pp. 11–12; and Center for Defense Information <www.cdi.org>.

[20] Kan, "China: Ballistic and Cruise Missiles," p. 12, citing Mark Stokes.

The CSS-7/DF-11/M-11 is similar to the DF-15 in basic design; i.e., it is a solid-fueled, road-mobile SRBM that is probably both conventional and nuclear-capable. In contrast to the DF-15, however, it is thought to have two stages and a much shorter range of 300 km.[21] The DF-11 was probably deployed with Chinese forces in the late 1990s, although some experts dispute this. The short range of the DF-11 presents challenges for missile defense systems due to its brief flight time of three minutes. Moreover, because its flight would remain within the atmosphere, most upper-tier ballistic missile defense systems would be unable to engage the missile. An improved, longer range version of the DF-11—the DF-11A—has been developed and might already be deployed in small numbers. China reportedly possesses several hundred DF-11s and DF-15s, most located in southeast China within range of Taiwan, and is continuing to produce the missiles at a rate of approximately 50 per year.[22]

The CSS-N-3/JL-1 is a two-stage, solid-fueled, 1,700 km range SLBM (submarine-launched ballistic missile) with a gyroplatform inertial guidance system and an on-board computer. The JL-1 was developed as China's first solid-fuel missile. Successful underwater test firings were conducted in 1988 but have not been repeated. As indicated above, the JL-1 later evolved into the DF-21 land-based system. China has reportedly deployed 12 single-warhead JL-1s aboard its one Xia-class nuclear ballistic missile submarine. U.S. intelligence sources believe that the JL-1 SLBM is not operational.[23]

The CSS-8/8610/M-7 is a two-stage[24] BSRBM designed from a modified HQ-2 surface-to-air missile (SAM) that is itself a modification of the Soviet SA-2 SAM with solid-

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[21] Contrary to recorded data on the DF-11, visual inspection from satellite photos suggest the missile may have only one stage. The author is indebted to Phillip Saunders and Tim McCarthy from the Center for Nonproliferation Studies at the Monterey Institute for this observation.

[22] Gill and Mulvenon, "China and Weapons of Mass Destruction"; Center for Defense Information <www.cdi.org>; and Kan, "China: Ballistic and Cruise Missiles," p. 13, citing Mark Stokes ("China's Strategic Modernization: Implications for the United States," U.S. Army War College, Strategic Studies Institute, September 1999) states: "In late 1999, it was reported that the PLA was expanding two new DF-11 bases in Fujian province, across the strait from Taiwan. One base at Yongan, about 275 miles from Taiwan, would host a PLA missile brigade with perhaps 16 launchers for up to 96 M-11 SRBMs…. Another new base at Xianyou would host a second PLA DF-11 brigade. Two bases would make a total of perhaps 32 launchers." China is expected to deploy 500 missiles by 2005 according to various Pentagon estimates.

[23] Kan, "China: Ballistic and Cruise Missiles," pp. 5, 9–10. Also, Gill and Mulvenon, "China and Weapons of Mass Destruction" state: "The limited range of the missile, the problems it has had in deployment and operation, and the limited experience of the Chinese in long-range submarine operations limits the value of this system as a strategic weapon."

[24] Some sources, such as the Federation of American Scientists, state that this missile is actually single stage.

fuel boosters and a liquid sustainer. The missile was originally developed for export and has been purchased by Iran. However, it is now believed that the missile's range has been extended up to 230 km for possible use against Taiwan.[25] If true, this would mean that some versions of the missile should be considered as SRBMs.

The DF-31 is a three-stage, land-mobile, solid-fueled missile. It will be China's next generation ICBM, possibly along with the DF-41 (if the latter is developed—see below). With a likely range of up to 8,000 km, the DF-31 could reach targets throughout Asia as well as Hawaii, Alaska, and the western continental United States. The missile is presumably intended to replace the liquid-fueled DF-4. After considerable delay, the DF-31 was first flight tested in August 1999, reportedly with decoys or penetration aids designed to defeat missile defenses. A second test was conducted in December 1999,[26] and at least one source states that a third test was conducted in November 2000.[27] Some reports have suggested that China has developed or is developing multiple independently targeted reentry vehicles (MIRVs) for the DF-31, perhaps with yields as small as 100–200 kilotons each.[28] While its origins are uncertain, the DF-31 is likely derived from the DF-23. Begun in 1978, the DF-23 development program set out to build a land-based, road-mobile, solid-fueled missile. Instead, it led to the submarine-launched JL-2 (see below). The land-based version of the DF-23 was renamed the DF-31 in January 1985. It is expected to be deployed within the next several years.[29]

With a range of 8,000 km, the Chinese DF-31 missile could reach targets throughout Asia as well as Hawaii, Alaska, and the western continental United States.

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[25] Kan, "China: Ballistic and Cruise Missiles," p. 13; and Evan Medeiros, "The Changing Character of China's WMD Proliferation Activities," National Intelligence Council website <www.cia.gov/nic/pubs>, November 1999.

[26] Kan, "China: Ballistic and Cruise Missiles," p. 14.

[27] Carnegie Endowment for International Peace <www.ceip.org>.

[28] See William Arkin and Robert S. Norris, "Chinese Nuclear Forces, 1999," *NDRC Nuclear Notebook*, November/December 2000; and Kan, "China: Ballistic and Cruise Missiles," p. 14. Center for Defense Information <www.cdi.org> states: "The series of nuclear tests conducted at China's Lop Nor nuclear site before the signature of the Comprehensive Test Ban Treaty were probably conducted to prove miniaturized, multiple warhead designs. By examining the estimated yields of these tests, it is likely that China is working on two new warheads, one with a yield of 100–200 kilotons, and another with a yield of 600–700 kilotons." See Appendix for greater detail on MIRVs.

[29] Gill and Mulvenon, "China and Weapons of Mass Destruction."

Table 2. China's Ballistic Missile Capabilities

Designation (U.S. designation)	Type of missile	Range/ Payload	Warhead Type (CEP)
DF-11 (CSS-7/M-11)	One- or two-stage SRBM	300 km/ 500–800 kg	One high explosive warhead or one 350 kiloton nuclear warhead (150–200 m)
DF-11A (M-18)	Two-stage MRBM	1,000–1,200 km/ 400–500 kg	One high explosive warhead or one 350 kiloton nuclear warhead (150–200 m)
DF-15 (CSS-6/M-9/ CSS-X-6)	Single-stage SRBM	600 km/ 500–950 kg	One high explosive warhead or one 50–350 kiloton nuclear warhead (300 m [under 50 m with GPS])
(CSS-8/M-7)	One- or two-stage (B)SRBM	150–230 km/ 190 kg	One high explosive warhead (unknown)
DF-21 (CSS-5)	Two-stage MRBM	2,000 km/ 600 kg	One 200–300 kiloton nuclear warhead (700 m)
DF-21A (CSS-5, Mod 2)	Two-stage MRBM	2,000 km/ 2,000 kg	One high explosive warhead (300–700 m)
DF-3 (CSS-2)	Single-stage MRBM	2,650 km/ 2,150 kg	One conventional warhead or one 1–3 megaton nuclear warhead (2,500–4,000 m)
DF-3A (CSS-2A)	Single-stage MRBM	3,000 km/ 2,150 kg	One 1–3 megaton nuclear warhead or possibly three 50–100 kiloton MRVs (1,000 m)
DF-4 (CSS-3)	Two-stage IRBM	5,500 km/ 2,200 kg	One 1–5 megaton nuclear warhead (1,500–3,500 m)
DF-5 (CSS-4)	Two-stage ICBM	12,000 km/ 3,000 kg	One 1–5 megaton nuclear warhead (500–3,000 m)
DF-5A (CSS-4A)	Two-stage ICBM	13,000 km/ 3,300 kg	One 4–5 megaton nuclear warhead (500 m)
* DF-31	Three-stage ICBM	8,000 km/ 700 kg	One 200-700 kiloton nuclear warhead or possibly 100-200 kiloton MIRVs (500 m)

continued next page.

Table 2. China’s Ballistic Missile Capabilities (cont.)

Designation (U.S. designation)	Type of missile	Range/ Payload	Warhead Type (CEP)
* DF-41	Three-stage ICBM	12,000 km/ 700–800 kg	One 200–300 kiloton or one 1 megaton nuclear warhead or three 50–90 kiloton MIRVs (700–800 m)
JL-1 (CSS-N-3)	Two-stage SLBM	1,700 km/ 600 kg	One 250 kiloton nuclear warhead (700 m)
* JL-2 (CSS-NX-4)	Three-stage SLBM	8,000 km/ 700 kg	One 250 kiloton nuclear warhead (500 m)

Sources: International Institute for Strategic Studies, *The Military Balance 2000–2001* (Oxford: Oxford University Press, 2001); Federation of American Scientists <www.fas.org>; Carnegie Endowment for International Peace <www.ceip.org>; Center for Nonproliferation Studies <http://cns.miis.edu>; and Center for Defense and International Strategic Studies <www.cdiss.org>.
Note: * indicates missile programs under development.

The CSS-NX-4/JL-2 SLBM is a submarine-launched version of the DF-31. It is a three-stage, solid-fueled missile. The JL-2 would thus have a much greater range than the JL-1. It is intended to be launched from the planned next-generation SSBN Type 094 submarine. Each Type 094 SSBN is expected to carry 16 JL-2s. The development of the land-based DF-31 was apparently given priority over this missile, however, perhaps because of the cost and difficulties encountered in building the Type 094 submarine. Both political and technological constraints may delay or even suspend the Type 094’s deployment, although some experts speculate that the JL-2 might be deployed on the new submarine within five years. Once deployed, it would be able to target parts of the continental United States from waters near China.[30]

The DF-41 is a three-stage, solid-fueled ICBM that, if deployed, would potentially be able to reach targets anywhere in the continental United States. As with the DF-31, this missile could possibly be armed with as many as three MRV or MIRVed warheads with yields of perhaps 50–90 kilotons each. The DF-41 would probably be hidden in caves like many other

[30] Gill and Mulvenon, “China and Weapons of Mass Destruction”; Kan, “China: Ballistic and Cruise Missiles,” p. 15; Center for Defense Information <www.cdi.org>; and Carnegie Endowment for International Peace <www.ceip.org>.

of China's nuclear missiles, but would be road-, rail-, or river-mobile. It is presumably intended to replace the aging DF-5/5A force, which Beijing will begin replacing around 2010. There is considerable doubt as to whether the DF-41 will be deployed, however. Although the DF-41 missile program was officially initiated in July 1986, the missile has never undergone flight-testing,[31] thus leading many observers to conclude that the program has been either suspended or cancelled.[32] These observers believe that a long-range version of the DF-31 will eventually be deployed to replace the DF-5/5A.

Existing trends suggest that China will significantly expand its inventory of mobile SRBMs through indigenous production. It could acquire as many as 750 to 1,000 SRBMs by 2015. Moreover, these missiles will likely be highly accurate, with CEPs of perhaps only 30–50 meters, and probably be primarily intended to serve counter-force purposes. Virtually all of these missiles will be deployed opposite Taiwan and thus will constitute a significantly increased threat to the island. China will also continue to improve the reliability, accuracy, and survivability of its longer-range missiles. It will probably not develop another new MRBM in addition to the DF-21. However, the DF-21 might be deployed in significant numbers (i.e., well over 100) within 15 years, both as a strategic delivery system to replace the obsolete DF-3A and as a conventionally-armed missile for possible deployment against Taiwan and perhaps U.S. forces in Japan. China might deploy even higher numbers of such missiles—and of its longer-range IRBMs as well—if both Japan and the United States deploy extensive upper-tier BMD systems in East Asia.[33]

The deployment of ICBMs in Asia in the next 10–15 years will be heavily influenced by the potential deployment of a U.S. NMD system.

China is already in the process of significantly modernizing its ICBM forces by enhancing their survivability and accuracy, and hence their credibility as a deterrent. Overall, the number and type of ICBMs that will be deployed in Asia during the next 10–15 years will likely be heavily influenced by the potential deployment by the United States of a NMD

[31] Gill and Mulvenon, "China and Weapons of Mass Destruction"; Kan, "China: Ballistic and Cruise Missiles," p. 15; Center for Defense Information <www.cdi.org>; and Carnegie Endowment for International Peace <www.ceip.org>.

[32] Kan, "China: Ballistic and Cruise Missiles," pp. 15–16; and Carnegie Endowment for International Peace <www.ceip.org>.

[33] The higher reentry speeds of IRBMs would make it more difficult for upper-tier TMD systems to intercept them.

system. If the United States moves to deploy even a limited NMD system within the coming decade, China will almost certainly increase the total number of its ICBMs and develop a range of technical countermeasures such as penetration aids and decoys. Beijing might also arm these missiles with MRV or MIRV warheads. The specific size and scope of the increase in China's ICBM arsenal will depend in part on Chinese expectations concerning the size and ultimate limitations of the U.S. NMD system. Initially, China might field a force of at least 100 to 150 single warhead ICBMs with two decoys each to ensure the survival of its deterrent force against the combined effect of a U.S. first strike and the use of the announced NMD system (which is designed to counter up to 24 reentry vehicles) to intercept a possible Chinese retaliatory strike.[34] However, this number could eventually be much higher, totaling at least 300 to 500 deployed strategic warheads (including MIRVed warheads) and possibly anti-satellite weapons, in anticipation of future significant increases in the size and capabilities of the U.S. NMD system.[35]

China is highly suspicious of U.S. assurances concerning the upper limits to be placed on any deployed NMD system as a result of agreements with Russia, funding limits, or various technical constraints. However, it is unlikely that China will enter into an arms race with the United States by seeking to match or even approximate the U.S. nuclear arsenal or to build a similar Chinese NMD system. Such an effort would require an enormous amount of time and resources, thereby undermining China's economic modernization program and delaying China's emergence as a major power. Most important, it is generally viewed by most Chinese observers as unnecessary, given China's continued belief that a larger, modernized, counter-value oriented missile force possessing relatively sophisticated countermeasures can overcome a U.S. NMD system (see below for more on this point).

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[34] Some U.S. government intelligence experts estimate that China would initially deploy as many as 200 missiles. See discussion in Michael J. Green and Toby F. Dalton, "Asian Reactions to U.S. Missile Defense," *NBR Analysis*, vol. 11, no. 3, p. 39.

[35] A larger Chinese missile force is already being deployed on a gradual basis in response to concerns over growing vulnerabilities caused by obsolescence. How large China's strategic missile force might grow in the absence of a U.S. NMD system is difficult to determine, however, but would likely amount to only a few "tens" or "dozens" (as opposed to hundreds) of warheads. Furthermore, the deployment of as many as 300 to 500 warheads might require China to resume both fissile material production and nuclear weapons testing, and thereby violate both the Fissile Materials Cutoff Treaty (FMCT) and the Comprehensive Test Ban Treaty (CTBT). It could also alter China's strategic doctrine to incorporate a more "ready" force capable of responding relatively quickly to a first strike. See Green and Dalton, "Asian Reactions to U.S. Missile Defense," p. 40.

However, the likelihood of a significantly larger Chinese missile force (possibly including hundreds of nuclear-capable land attack cruise missiles [LACMs] and ballistic missile warheads in the hundreds) as well as the acquisition of ground- or space-based anti-satellite weapons (possibly with Russian assistance) will increase significantly if support grows in the United States for the deployment of a “thick” NMD system offering zero leakage, or for the deployment of an even larger system (including, perhaps, space-based weapons) designed to free Washington from attempts at nuclear coercion by any small or mid-range nuclear power in a future international crisis. Such moves will likely be interpreted by Beijing as confirmation of suspicions that Washington seeks to create a very large and sophisticated NMD system in order to neutralize China’s nuclear deterrent and thereby dominate and contain China.

India

India has an extensive, largely indigenous ballistic missile program, including infrastructures for both solid- and liquid-fueled missiles. Although many ballistic missiles are currently under development, to date India probably has deployed only one type of missile: the Prithvi-1 (SS-150) SRBM.

The Prithvi class of missiles is a road-mobile, single-stage, liquid-fueled SRBM that employs propulsion technology from the Soviet SA-2 SAM. The Prithvi is otherwise Indian in design. The Prithvi program began in 1983, and the missile was first test-fired in 1988. Three basic types of Prithvis currently exist (two are under development, but may never reach deployment). The Prithvi-1 has a range of approximately 150 km, sufficient to strike any significant target in Pakistan if deployed anywhere along the Indian border. The Indian Army has apparently ordered 100 of these missiles, which reportedly can be equipped with five types of conventional warheads. Making use of the range-payload trade-off, the Prithvi-2/SS-250 is a lighter, longer-range (250 km) variant of the Pirthvi-1 used by the Indian Air Force, but is basically the same missile. It is currently undergoing flight-testing, but, although ready for production, it may never be deployed. Some experts insist that both Prithvis 1 and 2 are nuclear-capable. Other analysts believe only the Prithvi-2 can carry nuclear warheads, and express doubt that the Prithvi-1 would be nuclear-tipped, given its short range, mobility, and liquid fuel supply. India has reportedly deployed one regiment of 12 Prithvi-1s with 3 to 5 launchers. However, the Indian government has stated that the missiles are not operationally deployed. India’s defense minister reportedly authorized production of 300 Prithvis in mid-2000, apparently in response to a test by Pakistan of the Ghauri-2, an intermediate-range and nuclear-capable ballistic missile.[36] India is also reportedly working on the Prithvi-3/SS-350, which had its first (unsuccessful) test-flight in April 2000.[37] The Prithvi-3 has a range of approximately 350 km and is believed to be derived from the Russian SA-2. (Also in its early development stage is the Dhanush, the Indian naval version of the Prithvi-3. The Dhanush may be a ship-to-ship ballistic missile. It was successfully flight-tested in September 2001, but it is not clear that production of the missile has begun.

India's second family of ballistic missiles is the Agnis 1, 2, and 3. The Agni-1 is a two-stage missile with a combination liquid-solid propulsion and a closed-loop inertial guidance system. It is thus capable of reaching significant targets in China. This missile was first test fired in 1989. After three test flights, India reportedly halted further work on the Agni-1 in the mid-1990s under U.S. pressure, claiming the missile was only a "technology demonstrator." However, in July 1997, after Pakistan's test of a 600 km range missile (the Hatf-3), India announced that it would give "high priority to the next phase of the Agni program"—the Agni-2.[38]

The Agni-2 is a rail-mobile, two-stage, nuclear-capable MRBM with a solid propulsion engine. The missile can reportedly be launched within 15 minutes, compared to almost half a day of preparation for the Agni-1. Moreover, the Agni-2 reportedly incorporates a far more accurate terminal navigation and guidance system that constantly updates information about the missile flight path using GPS and ground-based beacons.[39] The missile is capable of reaching targets across Pakistan and in substantial portions of China. It was first flight tested in April 1999 over a distance of 1,250 km and a second time from a mobile launcher on January 2001, reportedly to a distance of approximately 2,000 km. A third test took place in late January 2002 during heightened tension between India and Pakistan and massive troop build-ups along the border.[40] (Indian Defense Minister George Fernandes described the missile as

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[36] "India's Slow-Motion Nuclear Deployment," *Proliferation Brief*, vol. 3, no 26 (September 2000), Carnegie Endowment for International Peace <www.ceip.org>; Canadian Security Intelligence Service <www.csis-scrs.gc.ca>; and Joseph Cirincione, "Indian Missile Deployments and the Reaction from China," paper presented at the *Conference on the Nuclearization of South Asia: Problems and Solutions*, UNESCO International School of Science for Peace, Como, Italy, May 20–23, 1999.

[37] Canadian Security Intelligence Service <www.csis-scrs.gc.ca>.

[38] Canadian Security Intelligence Service <www.csis-scrs.gc.ca>; and Federation of American Scientists <www.fas.org>.

[39] Federation of American Scientists <www.fas.org>.

[40] Celia Dugger, "India Test-Fires Intermediate-Range Missile," *The New York Times*, January 25, 2002, from Federation of American Scientists <www.fas.org>.

Table 3. India's Ballistic Missile Capabilities

	Designation (U.S. designation)	Type of missile	Range/ Payload	Warhead Type (CEP)
	Prithvi-1 (SS-150)	Single-stage SRBM	150 km/ 1,000 kg	Conventional warhead (1,500 m)
*	Prithvi-2 (SS-250)	Single-stage SRBM	250 km/ 500–750 kg (1,500 m)	Conventional armed or possibly nuclear warhead
*	Prithvi-3 (SS-350)	Unknown SRBM	350 km/ 500–1,000 kg	Unknown (unknown)
*	Agni-2	Two-stage MRBM	2,000 km/ 1,000 kg (44 m)	One high explosive warhead or one 200 kiloton nuclear warhead
*	Agni-3	Two-stage IRBM	3,000–5,000 km/ unknown (44 m)	One high explosive warhead or one 200 kiloton nuclear warhead
*	Surya	Unknown IRBM or ICBM	3,250–12,000 km/ unknown	Unknown (unknown)

Sources: International Institute for Strategic Studies, *The Military Balance 2000–2001* (Oxford: Oxford University Press, 2001); Federation of American Scientists <www.fas.org>; Carnegie Endowment for International Peace <www.ceip.org>; Center for Nonproliferation Studies <http://cns.miis.edu>; and Center for Defense and International Strategic Studies <www.cdiss.org>.
Note: * indicates missile programs under development.

operational in March 2001.) Officials of the Indian Defense Research and Development Organization (DRDO) disclosed plans to produce 20 Agni-2 missiles in 2001 and 2002. It is unclear, however, whether the Agni-2 is operational at present. Missile production and deployment schedules remain unclear. At most, a very small number of Agni-2 missiles exist.[41] With the upcoming Agni-3, it is unlikely India will mass-produce the Agni-2, which cannot reach Beijing or targets in northern China. The Agni-3 is a solid-fueled IRBM that has reportedly been under development since the late 1990s. One or two test models may already

[41] Canadian Security Intelligence Service <www.csis-scrs.gc.ca>; and Carnegie Endowment for International Peace <www.ceip.org>.

be in existence. This missile would enable India to target Beijing.[42] Although India has claimed that the Agni-3 will be used only to carry a conventional warhead, the cost of the system would be difficult to justify unless used as a nuclear weapon delivery vehicle.[43]

Little is known about the new Surya, which is under development. Estimates of the range of this missile vary widely, from 3,250 km to 12,000 km. It has reportedly been under development since at least early 1999, but no tests have occurred. The Surya program is supposedly a modification from the polar satellite launch vehicle (PSLV) and Agni-2. In November 1999, India's Minister of State for Defense Bachi Singh Rawat said that the Surya "might be tested soon." However, one independent analyst has stated that there are no indications that the actual flight hardware for an ICBM is ready for testing, and judged that "progress on such a weapon is likely to be slow."[44]

India's successful space launch program has been an important element in its ballistic missile program, providing research and facilities.[45] India's space launch vehicle (SLV) projects achieved credibility after placing 40 kg Rohini satellites into near-earth orbit three times in the early 1980s. India also launched a satellite with a PSLV in May 1999, and another satellite with a more advanced geosynchronous satellite launch vehicle (GSLV) in April 2001.[46] The Pentagon stated in April 1996 that India could convert its SLVs into IRBMs or ICBMs quite easily but "…has shown no indications of doing so.... It has already built guidance sets and warheads, key components needed to convert an SLV into a ballistic missile." Moreover, the 1998 Rumsfeld

The Pentagon has stated that India could convert its space launch vehicles into IRBMs or ICBMs quite easily.

[42] Canadian Security Intelligence Service <www.csis-scrs.gc.ca>.

[43] Federation of American Scientists <www.fas.org>.

[44] Canadian Security Intelligence Service <www.csis-scrs.gc.ca>. See also Vivek Raghunvanishi, "India to Develop Extensive Nuclear Missile Arsenal," *Defense News*, May 24, 1999; Institute for Foreign Policy Analysis, "Exploring U.S. Missile Defense Requirements in 2010: What Are the Policy and Technology Challenges?" April 1997; David Tanks, "Ballistic Missiles in South Asia: Are ICBMs a Future Possibility?"; and *Rumsfeld Report*, Appendix III: Unclassified Working Papers.

[45] Federation of American Scientists <www.fas.org>.

[46] India Abroad News Service <www.indiainnewyork.com/india-news/apr2001/sattell.shtml>. This report states that: "The three-stage, 161 foot high GSLV is the most technologically challenging project so far undertaken by the Indian space program. The flight signals a significant shift toward self-reliance in the rocket industry…. The three-stage GSLV uses a cryogenic engine (supplied by Russia) for the final stage. The engine uses liquid hydrogen and liquid oxygen, stored in two separate tanks and connected by an interstage structure, as propellants."

Commission report noted, “While it develops its long range ballistic missiles, India’s SLVs provide an option for an interim ICBM capability.”[47]

India will probably place most emphasis in the next 10–15 years on the development of WMD-armed MRBMs and IRBMs deployed against Pakistan and China. (It might still produce a significant number of SRBMs, most likely only for political reasons related to inter-service rivalry within the military.) It is difficult to estimate how many MRBMs will be deployed, but they will probably number at least in the tens, and perhaps considerably more if China significantly increases its MRBM and IRBM arsenal in response to U.S. and regional BMD deployments. India will also almost certainly develop an IRBM capable of reaching Beijing and Shanghai, thus placing it on an equal strategic footing with China. However, the number of such missiles will likely be small. Although some reports suggest that India’s Surya missile program might result in a genuine ICBM, many experts believe it is highly unlikely that Delhi will undertake such an effort. India is striving to improve relations with the only possible countries against which such a missile might be deployed—the United States and Russia—and would not want to seriously disrupt this effort.

India will almost certainly develop an IRBM capable of reaching Beijing and Shanghai, placing it on equal strategic footing with China.

Japan

Japan does not currently possess ballistic missiles and lacks a full suite of technologies for guidance systems, warheads, and heat shielding. However, it has an active commercial space launch program using several types of solid-fueled rockets, which could provide the basis for a long-range ballistic missile program. The M-3S-2 was first launched in 1985, placing a 780 kg payload in a 250 km orbit and propelling Japan’s first interplanetary probes toward Halley’s Comet. Should it be converted into a ballistic missile, the M-3S-2 is considered to be capable of traveling 4,000 km with a 500 kg payload. Development of the new M-V rocket began in 1989 and it was first launched in 1995. It weighs 130,000 kg, more than twice as much as the 61,700 kg M-3S-2. The M-V reportedly will be able to place a 1,800 kg payload into low earth orbit or inject a 300–400 kg payload into space for planetary surveys, and is believed to

[47] *Rumsfeld Report*, Appendix III: Unclassified Working Papers; and Canadian Security Intelligence Service <www.csis-scrs.gc.ca>. The first direct crossover of technology between the ballistic missile and the space launch programs occurred in the design and development of the Agni, which utilized the SLV-3 as its first stage rocket. Cirincione, “Indian Missile Deployments and the Reaction from China.”

be capable of modification for ICBM roles.[48] Japan is reportedly developing three additional SLVs: the 4,000 km M-3, the 12,000 km H-1, and the 15,000 km H-2.

North Korea

The Scud-B is a relatively primitive, Soviet-designed, single-stage, liquid-fueled, road-mobile SRBM. North Korea acquired its first Scud-Bs from Egypt in 1981 and began reverse-engineering them in the early 1980s with technical assistance from China and Iran.[49] The Scud-C is a slightly improved version of the Scud-B, with a longer range but smaller payload, and a three-gyroscope inertial guidance system. Full-scale production of the missile began in 1991. North Korea can reportedly produce four to eight Scud-Bs and -Cs per month and currently has over 500 Scuds in its total inventory, with at least 30 launchers. Most of these missiles are deployed just north of the Demilitarized Zone and are able to reach targets throughout South Korea.[50]

The Nodong-1 is a Scud-derived, single-stage, liquid-fueled, road-mobile MRBM. It is transported and launched by a Korean-produced copy of the Russian MAZ 543P TEL. North Korea applied basic Scud technology to produce this missile (as well as the Nodong-2, discussed below) in the early 1990s. The missile could reach most of Japan, including U.S. military bases at Yokota, Yokosuka, and Okinawa, and is theoretically capable of delivering a nuclear weapon. Although flight-tested only once in May 1993, the Nodong-1 was reported by the Pentagon as operational in June 1998. The July 1998 Rumsfeld Commission maintained that it "was operationally deployed long before the U.S. Government recognized that fact" and that it was "highly likely that considerable numbers of Nodongs have been produced." Although the Federation of American Scientists estimated the Nodong inventory at between 12 and 36 missiles as of June 2000, Asian experts interviewed by the author estimate that the total number of deployed Nodong-1 missiles might exceed 100. This

The North Korean missile, Nodong-1, could reach most of Japan, including U.S. military bases at Yokota, Yokosuka, and Okinawa.

[48] Federation of American Scientists <www.fas.org>.

[49] Some experts feel Russia was more directly responsible for the transfer of the Scud-B to North Korea, or at least was involved in later Scud-B transfers.

[50] Canadian Security Intelligence Service <www.csis-scrs.gc.ca>; Center for Nonproliferation Studies < http://cns.miis.edu>; and Center for Defense and International Security Studies <www.cdiss.org>.

Table 4. North Korea's Ballistic Missile Capabilities

Designation (U.S. designation)	Type of missile	Range/ Payload	Warhead Type (CEP)
Hwasong 5 (Scud B)	Single-stage SRBM	280–330 km/ 985–1,000 kg	One high explosive or chemical warhead (450 m)
Hwasong 6 (Scud C)	Single-stage SRBM	500–700 km/ 500–700 kg	One high explosive or chemical warhead (50–500m)
Nodong-1/Rodong (Scud D)	Single-stage MRBM	1,000 km/ 1,000 kg	One high explosive or chemical warhead, possibly one 50 kiloton nuclear warhead (190–700 m)
* Nodong-2	One- or two-stage MRBM	1,500 km/ 770–1,000 kg	Unknown (unknown)
* Taepodong-1	Two- or three-stage MRBM	1,500–2,200 km/ 1,000 kg	Unknown (unknown)
* Taepodong-2	Two-stage IRBM/ICBM	3,500–6,000 km/ 1,000 kg	Unknown (unknown)

Sources: International Institute for Strategic Studies, *The Military Balance 2000–2001* (Oxford: Oxford University Press, 2001); Federation of American Scientists <www.fas.org>; Carnegie Endowment for International Peace <www.ceip.org>; Center for Nonproliferation Studies <http://cns.miis.edu>; and Center for Defense and International Strategic Studies <www.cdiss.org>.
Note: * indicates missile programs under development.

number has also been mentioned by the senior U.S. military commander in South Korea.[51] North Korea could be attempting to mate the Nodong series with a WMD warhead. South Korean sources have stated that the Nodong could carry either a small nuclear weapon or a VX chemical warhead. In August 1994, a Chinese source reported that the Nodong could deliver either a 50 kiloton nuclear warhead or nerve gas.[52] It is far more likely that North Korea would mate the Nodong with a chemical or biological, rather than a nuclear, warhead. This is because the relatively primitive nature of North Korea's nuclear weapons program

[51] General Thomas Schwartz, Commander in Chief of U.S. Forces Korea, testified on March 15, 2000, that North Korea possessed about 100 Nodong missiles. See Green and Dalton, "Asian Reactions to U.S. Missile Defense," p. 44, fn. 53.

[52] Green and Dalton, "Asian Reactions to U.S. Missile Defense," p. 44, fn. 53.

suggests that it does not currently possess, nor will it likely acquire in the foreseeable future, a nuclear warhead small and light enough to deploy on a ballistic missile.[53]

The Taepodong-1 appears to utilize a Nodong-1 liquid-fueled first stage and a Scud-B second stage. However, in August 1998 Pyongyang test-fired a Taepodong-1 with a solid-fueled third stage in an unsuccessful attempt to launch a satellite. The final stage landed off the Alaskan coast, a clear demonstration of how close North Korea has come to ICBM technology (if indeed the solid-fueled, third stage booster was indigenously produced).[54] The Taepodong-2 is a longer-range version of the Taepodong-1. Both the first and second stages of the Taepodong-2 have been modified. The first resembles the first stage of the Chinese DF-4, and the second is either derived from a Chinese M-11 or a modified Nodong-1 second stage. These changes could theoretically allow the Taepodong-2 to achieve a 6,000 km range. Launched from North Korea, it could conceivably strike Guam and parts of Alaska and Hawaii. Some observers believe that North Korea might attempt to develop a three-stage version of the Taepodong-2, with a possible range of 10,000 km. Such a missile could reach most of the continental United States from North Korea. However, other experts doubt that North Korea is currently working on such a long-range ICBM and also point out that many technical difficulties stand in the way of such an effort.

In 1998 the final stage of a Taepodong-1 missile landed off the Alaskan coast, demonstrating how close North Korea has come to ICBM technology.

North Korea will likely continue to expand its existing inventory of SRBMs, although it is difficult to say what size force might eventually emerge. Pyongyang might put more effort into developing MRBMs capable of striking U.S. bases on the far side of Japan. However, it will undoubtedly encounter strong resistance from both Tokyo and Washington to this effort. As the Taepodong-2 illustrates, North Korea might also attempt to develop an IRBM/short-range ICBM to potentially threaten parts of the westernmost territories of the United States.

[53] Some sources list a variant of the Nodong-1, the Nodong-2, which has a longer range as a result of using a lightweight aluminum-magnesium alloy for the main booster instead of steel. If this missile exists, it would represent the longest-range system that could be developed from Scud-derived technology, and would be able to strike anywhere in Japan. See Center for Defense and International Security Studies <www.cdiss.org>, especially <www.cdiss.org/nkorea_b.htm>.

[54] Canadian Security Intelligence Service <www.csis-scrs.gc.ca>.

Yet U.S. opposition to such a move would be even greater than to the deployment of North Korean MRBMs and could precipitate a political-military crisis between Pyongyang and Washington. Moreover, some experts argue that technical constraints prevent North Korea from developing a credible long-range IRBM/short-range ICBM capable of striking U.S. territory within the next 10 years, and the likely inaccuracy of such a missile would make it ineffective as a weapon unless armed with a nuclear warhead. It is unknown when North Korea might possess such a warhead. Thus, at most one can only say that the potential exists for North Korea to deploy a WMD-tipped missile capable of striking a small portion of the United States within the next 10–15 years. There is no conclusive evidence that North Korea is currently attempting to develop a longer-range ICBM, although some experts have speculated that such a missile might be created by extending the range of the Taepodong-2.

Pakistan

The Hatf-1 is a solid-fueled, indigenously produced BSRBM. Development of the missile began in the mid-1980s, to counter India's Prithvi program. As many as 80 missiles have reportedly been deployed, but they are regarded as unreliable and relatively inaccurate and hence are of limited use. Development of a longer-range version of the missile—the Hatf-2—also began in the 1980s. This missile was tested in May 2002. Pakistani reports on these recent tests also referred to the missile as the Abdali. Both of the Hatf missiles were probably built with Chinese assistance.[55]

The Hatf-3 is a solid-fuel, two-stage SRBM with similarities to the Chinese M-11 (DF-11) and perhaps M-9 (DF-15) missiles. Some sources list it as the Shaheen (see below). The Hatf-3 is being developed with Chinese assistance. It was first tested in 1997, after reports that India had deployed the Prithvi missile close to the Indian-Pakistani border. In May 2002, Pakistan again tested a Hatf-3 (which some reports referred to as the Ghaznavi), and claimed that its range was 290 km.[56]

In tandem with and supporting the Hatf programs, Pakistan also acquired the M-11 ballistic missile system and associated equipment from China. Approximately 30 M-11

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[55] The Hatf-2 might be a variant of the M-11 missile, although some experts believe that it is based on French sounding rocket engines.

[56] Carnegie Endowment for International Peace <www.ceip.org>.

missiles were transferred to Pakistan in the early 1990s, although both Pakistan and China deny this. The missiles are stored in crates at the Sargodha Air Force Base. Although these missiles are apparently not currently "operational," they can probably be unpacked, mated with launchers, and made ready for launch in 48 hours. Pakistan may have developed conventional warheads for these missiles, and Chinese experts have reportedly trained the Pakistani unit assigned to fire the missiles. These M-11 missiles are probably very similar to the Hatf-3. Although the M-11 is considered nuclear-capable, it is doubtful that Pakistan would be able to develop a miniaturized nuclear warhead for the missile without first undertaking flight-testing and nuclear weapon testing. However, Chinese assistance might have made it possible for Pakistan to acquire such a warhead without testing. It is very likely that, if deployed, the M-11 (and the Hatf-3) would carry a WMD warhead.[57]

The Pakistani military unit assigned to fire M-11 missiles has reportedly been trained by Chinese experts.

The Shaheen-1 is a single-stage, solid-fueled SRBM. It was first test-flown in April 1999. Analysts believe this missile may be related to the Chinese M-9, though there is a great deal of debate over this issue.[58] The Shaheen-2, believed to have been displayed in the annual Pakistan Day parade in March 2000, is a much longer-range, road-mobile, two-stage, solid-fueled MRBM, with a range of 2,000–2,500 km and a payload of 1,000 kg. The Shaheen-2 is still apparently in the design stage. It may be ready for flight-testing in the near future, and once completed would be able to strike any target in India.[59]

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[57] Center for Defense Information <www.cdi.org>; Canadian Security Intelligence Service <www.csis-scrs.gc.ca>; and Carnegie Endowment for International Peace <www.ceip.org>. See also S. Chandrashekar, "An Assessment of Pakistan's Missile Capability," *Jane's Strategic Weapon Systems*, March 1990, p. 4, fn. 15.

[58] There is considerable confusion surrounding the Pakistani missile projects developed with Chinese assistance. In addition to transferring complete missiles, the Chinese also set up a turnkey missile production plant in Pakistan. It is uncertain whether the Pakistanis have used the plant to produce copies of the M-11s, Hatf-3s, or more advanced missiles like the Shaheen series. Because the characteristics of the Hatf-3 and the Shaheen-1 are unclear, it is not certain on which Chinese missile they are based. There are suspicions that the M-11, M-9, and M-18, or at least their technologies, are involved in the Shaheen family of missiles, but it is uncertain whether the Shaheen missiles are exact Chinese M-series replicas, licensed out to Pakistan, or also have some indigenously designed aspects. It may be that there are both imported and licensed versions.

[59] Carnegie Endowment for International Peace <www.ceip.org>; and Canadian Security Intelligence Service <www.csis-scrs.gc.ca>.

Table 5. Pakistan's Ballistic Missile Capabilities

Designation	Type of missile	Range/ Payload	Warhead Type (CEP)
Hatf-1	Single-stage BSRBM	60–80 km/ 500 kg	One high explosive warhead (unknown)
Hatf-2	Two-stage SRBM	280–300 km/ 500 kg	One high explosive warhead (unknown)
Hatf-3 (Shaheen or Ghaznavi)	Two-stage SRBM	290–600 km/ 500 kg (unknown)	One high explosive warhead, potentially nuclear capable
M-11	Two-stage SRBM	280–300 km/ 800 kg	One high explosive warhead (unknown)
Shaheen-1	Single-stage SRBM	700–800 km/ 1,000 kg (unknown)	One high explosive warhead, potentially nuclear capable
* Shaheen-2	Two-stage MRBM	2,000–2,500 km/ 1,000 kg	Probably a nuclear warhead (unknown)
Ghauri-1	Single-stage MRBM	1,000–1,500 km/ 500–750 kg	One high explosive warhead, potentially nuclear capable (unknown)
* Ghauri-2	Unknown MRBM	2,000–3,000 km/ 700 kg	Probably a nuclear warhead (unknown)

Sources: International Institute for Strategic Studies, The Military Balance 2000–2001 (Oxford: Oxford University Press, 2001); Federation of American Scientists <www.fas.org>; Carnegie Endowment for International Peace <www.ceip.org>; Center for Nonproliferation Studies <http://cns.miis.edu>; and Center for Defense and International Strategic Studies <www.cdiss.org>.
Note: * indicates missile programs under development.

The Ghauri-series (Ghauri-1 and Ghauri-2) of single-stage, liquid-fueled MRBMs could strike any target in India. Pakistan claims that both missiles could carry a nuclear warhead. The Ghauri is likely based on the North Korean Nodong and the Ghauri-2 might be based upon the North Korean Taepodong, probably following a transfer of completed missiles from Pyongyang. The Ghauri-1 was tested in April 1998. The exact number of Ghauri-1 missiles in Pakistan's arsenal is unknown, but some experts believe that Pakistan possesses at least 12.

The Ghauri-2 might not yet be in Pakistan's inventory. There have been reports, however, that it underwent static-engine testing in April 1999. In addition to the Hatf-3 Ghaznavi missile, a Ghauri missile (also referred to in some sources as the Hatf-5) was test-fired in May 2002.[60]

Pakistan will almost certainly expand the number and type of SRBMs in its inventory over the next 10–15 years, given Islamabad's robust SRBM research and development program, the relative quality of its SRBMs (due primarily to Chinese assistance), and its growing reliance—in light of the ongoing decline of its conventional forces—on WMD for defense. These missiles will probably remain separate from their warheads and under strict central control. Pakistan will probably place more of an emphasis than India on the development of MRBMs alone (rather than the longer-range IRBMs), since these missiles can reach targets throughout India. More than one type of MRBM will likely be deployed, and the total number of MRBMs will probably be in the tens.

Given Islamabad's growing reliance on WMD, Pakistan will almost certainly expand its SRBM inventory over the next 10–15 years.

South Korea

South Korea currently possesses two types of SRBMs: the NHK-1 and the NHK-2. These ballistic missiles are reverse-engineered from the U.S. Nike-Hercules SAM, with modifications designed to increase their range and accuracy and transform them to strike ground targets. The NHK-1 was developed in 1975, and the NHK-2 was test-fired in 1978. The latter reportedly possessed improved electronics and warhead munitions and could strike targets up to a distance of 250 km, depending upon the weight of the payload. This missile would have violated a 1979 South Korean pledge—contained in a Seoul-Washington memorandum of understanding—not to build any ballistic missiles with a range exceeding 180 km.[61] However, the United States agreed in September 2000 that South Korea should be able to build missiles compliant to Missile Technology Control Regime (MTCR) standards—which

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[60] Carnegie Endowment for International Peace <www.ceip.org>; and Center for Defense and International Security Studies <www.cdiss.org>.

[61] Although U.S. inspectors confirmed in 1990 that the missile's 180 km range was technically in compliance with the bilateral agreement, they also concluded that the NHK-2 could be modified to hit targets at a distance of 250 km.

allows for missiles up to a 300 km range and a 500 kg payload—if Seoul were to become a member of the MTCR. Some experts have implied that the NHK-2 could be modified to carry a nuclear explosive device.[62]

South Korea has stepped up its efforts in recent years to produce missiles indigenously. The NHK-A is the successor to the NHK-2. Very little information is available on this missile in unclassified literature. It might have a range of approximately 320 km, which, if true, would represent a violation of the MTCR. Moreover, South Korea might be attempting to build ballistic missile prototypes with a range of 500 km (enabling it to target all of North Korea), albeit only for "research purposes."[63]

While South Korea has not indicated that it has plans to build missiles other than those mentioned above, it does have an ambitious space launch program and has already developed a family of civilian SLVs. The single-stage KSR-1, developed in 1993 and the second in the KSR family, could be capable of modifications to become a ballistic missile with a 200 kg payload and a range of 150 km. The KSR-2, first launched in 1997, is a two-stage rocket that reportedly carried a 150 kg scientific observation unit to an orbit of 151.5 km. Although South Korea has not indicated that it intends to convert the KSR-2 into a ballistic missile, unconfirmed reports suggest that it could be used as a ballistic missile with a range from 100 to 900 km.[64] Furthermore, the South Korean space program plans to build a satellite launch facility by 2005, where the Korea Aerospace Research Institute (KARI) intends to develop booster rockets, which could be easily transferable to IRBM and ICBM applications.[65]

South Korea might be attempting to build ballistic missile prototypes, albeit only for "research purposes," that will enable it to target all of North Korea.

[62] Center for Defense and International Security Studies <www.cdiss.org>; and *Rumsfeld Report*, Appendix III: Unclassified Working Papers: System Planning Corporation: Non-Proliferation Issues—South Korea.

[63] Canadian Security Intelligence Service <www.csis-scrs.gc.ca>; and *Rumsfeld Report*, Appendix III: Unclassified Working Papers: System Planning Corporation: Non-Proliferation Issues—South Korea.

[64] Jane's Strategic Weapons Systems.

[65] Jane's Strategic Weapons Systems; Canadian Security Intelligence Service <www.csis-scrs.gc.ca>; and *Rumsfeld Report*, Appendix III: Unclassified Working Papers: System Planning Corporation: Non-Proliferation Issues—South Korea.

Table 6. South Korea's Ballistic Missile Capabilities

Designation missile	Type of Payload	Range/ (CEP)	Warhead Type
NHK-1, NHK-2	Two-stage SRBM	150–250 km/ 300 kg	One high explosive warhead (unknown)
* NHK-A (Hyon Mu)	Two-stage SRBM	180–320 km/ 300 kg	One high explosive warhead (unknown)

Sources: International Institute for Strategic Studies, *The Military Balance 2000–2001* (Oxford: Oxford University Press, 2001); Federation of American Scientists <www.fas.org>; Carnegie Endowment for International Peace <www.ceip.org>; Center for Nonproliferation Studies <http://cns.miis.edu>; and Center for Defense and International Strategic Studies <www.cdiss.org>.
Note: * indicates missile programs under development.

South Korea will probably increase its inventory of SRBMs, but the size and sophistication of this force will depend to a great degree on its assessment of the larger political and military environment on the Korean Peninsula. Seoul's current emphasis on improving relations with Pyongyang, as well as likely U.S. pressure, could serve as a significant brake on future missile deployments. For similar reasons, it is also unlikely that South Korea will attempt to develop longer-range ballistic missiles from its burgeoning SLV program. However, support for such missiles could conceivably emerge over the long term if Korea begins to move toward a posture that is more independent of the United States.

Taiwan

The Ching Feng is a single-stage, liquid-fueled BSRBM similar to the U.S. Lance. Israel is believed to have aided Taiwan in building this missile. However, even though the Ching Feng is believed to have become operational in the early 1980s, it may have been terminated under U.S. pressure. Its short range makes it inadequate as an offensive weapon against the Chinese mainland if launched from Taiwan proper, although it could reach the mainland if launched from Taiwan's offshore islands.[66]

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[66] Center for Defense and International Security Studies <www.cdiss.org>.

Table 7. Taiwan's Ballistic Missile Capabilities

Designation	Type of missile	Range/ Payload	Warhead Type (CEP)
Ching Feng	Single-stage BSRBM	100–130 km/ 275–400 kg	One high explosive warhead (unknown)
* Tien Ma	Unknown SRBM	950 km/ 500 kg	One high explosive warhead (unknown)

Sources: International Institute for Strategic Studies, *The Military Balance 2000–2001* (Oxford: Oxford University Press, 2001); Federation of American Scientists <www.fas.org>; Carnegie Endowment for International Peace <www.ceip.org>; Center for Nonproliferation Studies <http://cns.miis.edu>; and Center for Defense and International Strategic Studies <www.cdiss.org>.
Note: * indicates missile programs under development.

Some officials of the Taiwanese government have at times denied that Taiwan possesses or is developing any missiles other than the above-mentioned Ching Feng, although other officials and scholars have suggested that at least some research and development is underway on missiles with ranges up to 1,000 km. Reports from China suggest that in 1995 Taiwan began developing a 950 km range solid-fueled missile—the Tien Ma—based on the Tien Kung-2 SAM. Some sources even suggest that these missiles are operational and have been deployed and mixed in with silo-based Tien Kung-2 sites near Taipei and on the offshore islands. However, no concrete evidence exists to confirm an active Taiwanese SRBM or MRBM program.[67]

Taiwan might develop an inventory of mobile SRBMs during the next 10–15 years as part of its ongoing effort to counter China's increasing military capabilities. However, the likely size and configuration of such a missile inventory is difficult to assess. Some observers believe that Taiwan might focus greater efforts on acquiring MRBMs (or even IRBMs) as part of a counter-strike deterrence capability against China if the United States decides not to sell Taiwan upper-tier BMD systems or to include Taiwan in a future East Asian BMD system.[68] However, the United States will almost certainly resist such deployments as an excessively provocative move and a violation of MTCR restrictions.

[67] Interviews, Taiwan, June 1998; and Canadian Security Intelligence Service <www.csis-scrs.gc.ca>.
[68] Green and Dalton, "Asian Reactions to U.S. Missile Defense," p. 28.

Ballistic Missile Transfers

A handful of the Asian countries with ballistic missile programs are currently involved in missile transfers, especially China, North Korea, and Pakistan.[69] The following summary of significant ballistic missile-related transfers focuses largely on the export of complete missiles, missile components, and missile-related technologies or knowledge. Future trajectories in ballistic missile transfers are prone to unpredictable shifts in political, social, and economic variables. During the past several years, some observers have argued that a combination of: 1) rapid increases in global and regional trade; 2) greater general access to the information, technology, and technicians needed for ballistic missile and WMD development; 3) increased cooperation among several aspiring powers for the purpose of acquiring missile or WMD capabilities; and 4) the increased availability of missile-related classified information and export-controlled technologies, will combine to increase greatly the future proliferation of ballistic missile technology in a variety of areas. In contrast, other observers argue that the overall global pace and scope of ballistic missile transfers has declined in recent years—especially the transfer of complete missiles—and will likely continue to do so, largely as a result of sustained U.S. pressure and because the economic and political incentives motivating missile transfers are weakening.

China

Since the 1980s, China has been more actively involved in the transfer of missiles and missile-related items than any other Asian state. Aside from cruise missiles transfers, China has carried out a wide variety of activities, including:

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[69] Russia first engaged in missile-related transfers in the 1950s and continued to the 1980s. Following the collapse of the Soviet Union, however, Moscow began to curb its missile transfers as part of its support for global nonproliferation efforts, and in 1995 Russia was admitted to the MTCR (although alleged missile transfers to Iran have raised questions about Russia's commitment to the regime). U.S. officials remain concerned about Russia's propensity to sell weapons to Iran but do not believe any complete MRBMs have been transferred. There is also some evidence of North Korean efforts to recruit Russian experts for their missile programs. These actions have raised doubts over Russia's commitment to nonproliferation. Deepening economic problems, sporadic or feeble enforcement efforts, and perhaps changing political and foreign policy priorities associated with a decline in U.S.-Russian relations could result in greater levels of missile transfers. Although large-scale exports of missiles and missile-related materials are unlikely, the range of possibilities regarding Russia's future missile transfers is wide.

• The sale of 30–35 DF-3 MRBMs, 10–15 missile transport vehicles, and related technical support services to Saudi Arabia in 1988 in a deal that was reportedly worth up to $3.5 billion. The missiles are nearing the end of their operational life, but U.S. sanctions could be triggered if China or Saudi Arabia "conspires or attempts to engage in" transfers of replacements.[70]

• A $285 million contract with Syria in late 1989 for approximately 30 M-9 missiles and launchers. This deal was subsequently cancelled under U.S. pressure, but China has since reportedly supplied Syria with technical expertise for its missile program and ingredients for solid rocket fuel.

• Sales to Iran in 1989 of 150–200 BSRBMs (8610/CSS-8), as well as technologies, equipment, and materials for the construction of a production line to facilitate Iran's indigenous development of the 8610 system.[71] According to the CIA, China had also provided guidance systems, rocket fuel, and computerized machine tools to boost Iran's missile programs. In August 1996, the China Precision Engineering Institute again agreed to sell Iran missile guidance systems.[72]

• A possible agreement in January 1990 between China and Iran on the export of M-9 missiles and production tooling. Iran probably financially supported the M-9's development (as it has done for North Korea's Nodong missiles). However, after Iran had signed the contract and paid for the missiles, the deal was cancelled—presumably under U.S. pressure.

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[70] Rodney W. Jones and Mark G. McDonough, with Toby Dalton and Gregory Koblentz, "Tracking Nuclear Proliferation: A Guide in Maps and Charts," *CEIP Report*, 1998.

[71] The 8610-related systems are below MTCR parameters and are not prohibited by international agreements. Based on Chinese assistance, however, Iran has probably developed a self-sufficient production infrastructure for short-range missiles. Medeiros and Gill state: "Iran may be using these production technologies to build subsystems for medium- and long-range systems, which are explicitly banned by the MTCR. The production technologies used to build the 8610 missile may also accelerate Iran's construction of indigenous missiles like the Shahab-3 or to improve the Scud-type missiles supplied by North Korea. Some reports suggest that China also may have transferred telemetry equipment for use when test launching medium-range missiles banned by the MTCR. Chinese officials continue to defend these deals by citing the dual-use nature of its technology exports to Iran and the lack of agreement between the United States and China on the MTCR technology annex." Evan S. Medeiros and Bates Gill, *Chinese Arms Exports: Policy, Players, and Process,* Carlisle: U.S. Army War College – Strategic Studies Institute, 2000.

[72] Jones and McDonough, "Tracking Nuclear Proliferation."

• The possible sale to Libya of 140 M-9 missiles in 1989 and the subsequent transfer by Libya to Syria of 80 missiles. Libya also reportedly failed in an attempt to acquire Chinese long-range missiles such as the DF-3.

• The possible export to Syria in the mid-1990s of M-11 missile guidance systems and aid in the construction of a Syrian missile production facility in 1992, which may be intended to produce M-9 and M-11 missiles. Chinese technical specialists are reportedly working to produce missile guidance systems for Syrian Scuds.[73]

• The provision of a wide range of missile assistance to Pakistan, including: 1) up to 30 M-11/DF-11 missiles, which were delivered in 1992 to Pakistan's Sargodha Air Force Base near Lahore; 2) M-11 TELs delivered in 1991; 3) likely assistance to indigenous Pakistani ballistic missile programs, including the Hatf-1, Hatf-2, Hatf-3, and Shaheen series of missiles; 4) the provision of 10 tons (200 drums) of ammonium perchlorate (found in solid missile fuel), which was seized in transit in Hong Kong in 1996; 5) assistance on missile guidance, including transfers of gyroscopes, accelerometers, and on-board computers; and 6) provision of elements of a missile production factory at the national defense complex in Fatehgarh (Fatehgunj), located in the Tarwanah suburb of Rawalpindi, 40 km west of Islamabad.[74]

• Sales since the early 1990s of dual-use missile technologies or missile-related components by individual Chinese companies. The most notable such sales include: 1) the export in 1992 of 300 tons of ammonium perchlorate to Syria; 2) the export in the same year to Libya of a shipment of lithium hydride, which has direct application to missile fuel production; 3) the export in 1994 of ammonium perchlorate to Iraq in direct violation of the UN embargo;

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[73] Rich Chapman, "PRC Military Weapons Sales," U.S. Pacific Command study, Honolulu, at <http://news.bbc.co.uk/low/english/world/asia-pacific/newsid_462000/462625.stm>.

[74] Production of the factory began in 1995, based on a decade-old contract. It is likely to produce M-11/DF-11 missiles under the Pakistani designation Hatf-3. China and Pakistan both have denied the existence of the plant. Chinese supply of complete missile systems or production technology covered by the MTCR would constitute a major violation of the MTCR guidelines and, according to U.S. law, should trigger Category I sanctions, which could block all trade between the United States and Chinese aerospace and electronics firms. Jones and McDonough, "Tracking Nuclear Proliferation." Medeiros adds: "Open sources are unclear whether this facility will be used to build complete missiles or just missile components and sub-systems; this determination will affect China's compliance with the MTCR. Thus, until this facility becomes operational, questions will remain about the nature of China's missile assistance to Pakistan and the degree to which China's actions are consistent with its MTCR pledges." Medeiros and Gill, *Chinese Arms Exports*.

4) the possible transfer in 1996 of missile components for Syria's North Korean Scud-C program, in addition to technical assistance for a Syrian solid rocket motor propellant program for building ballistic missiles; and 5) the sale to North Korea since 1999 of a variety of dual-use, missile-related technologies, including accelerometers, gyroscopes, specialized steel and machinery used to build missile airframes, and unspecified space technologies. This assistance has likely been applied to Pyongyang's Scud, Nodong, and Taepodong programs. These transfers may have occurred without Beijing's approval, raising questions about the Chinese government's ability to control illegal commercial activity and enforce China's nonproliferation commitments.[75] There are also indications that Chinese export firms have sold missiles to clients in the Middle East via North Korean ports.[76]

As the above suggests, the scope and character of China's missile-related exports have undergone significant changes over time. For example, in the past ten years, the recipients of China's missile exports have diminished in number to include Iran, Pakistan, and, to a lesser extent, North Korea. Furthermore, China has moved away from the sale of complete missile systems to exporting subsystems, production technologies, dual-use missile technologies, and technical expertise, sometimes transferred to client nations under the guise of other types of technical assistance. Many of these transfers are not explicitly covered by multilateral control regimes, and China's missile nonproliferation commitments are often vague and unenforced.[77]

In the past ten years, China's missile-related exports have diminished to just Iran, Pakistan, and North Korea.

Significant concerns persist about China's interpretations of its pledges. For example, despite Beijing's commitment to abide by the MTCR, many Chinese officials have criticized the arrangement as a discriminatory regime that relies on double standards and that focuses too heavily on the supply side of the issue. In particular, they are quick to point out that the

[75] Chapman, "PRC Military Weapons Sales"; and Medeiros and Gill, *Chinese Arms Exports*.

[76] Chapman, "PRC Military Weapons Sales."

[77] According to Medeiros and Gill, "Agreements reached by senior U.S. and Chinese leaders are reportedly opposed by many parts of the Chinese bureaucracy. Moreover, many Chinese firms often have deep relationships with their 'customers' in countries such as Pakistan and do not share the government's commitment to nonproliferation. Thus, Beijing has difficulty controlling their export activities. This situation is especially true in the missile realm because China lacks regulations covering these items; thus, the government has no legal basis to monitor or punish firms. In addition, in China's original MTCR formulation, Beijing never agreed to accept the MTCR annex, which specifies all of the technologies controlled by this regime. China's reluctance to accept the annex has resulted in the continuation of missile technology exports to Iran, Pakistan, and North Korea." Medeiros and Gill, *Chinese Arms Exports*.

MTCR does not control exports of strike aircraft, which arguably are better delivery vehicles for WMD than missiles, and which the United States sells all over the world. Also, China's missile nonproliferation commitments are viewed by many Chinese as bilateral, political promises made in the context of U.S.-China bargaining. As a result China has at times tried to link its missile technology exports to changes in U.S. policy, such as reductions in U.S. arms sales to Taiwan. Chinese officials and scholars argue that continued U.S. arms sales—particularly missile defense exports to Taiwan—constitute a form of missile proliferation. Chinese officials believe that China should only become a member of the MTCR if the United States halts its military sales to Taiwan. Chinese Foreign Ministry officials argue that "only when the United States respects China's security concerns about U.S. weapons exports to Taiwan will China seriously consider U.S. security concerns about China's missile technology cooperation with Iran and Pakistan."[78] For this reason, China's commitment to nonproliferation is often viewed as questionable at best, and it is uncertain whether and to what degree Beijing will honor many of its previous promises, such as the November 2000 declaration to establish formal controls over missile-related and dual-use components in return for the U.S. lifting its ban on the use of Chinese SLVs for launching U.S.-made satellites.[79]

The nature of China's future missile transfers will undoubtedly be affected by a wide range of factors, including the general state of U.S.-China relations, Beijing's strategic priorities in key areas along its periphery, and the ability and willingness of the central government to supervise the possible missile export-related activities of subordinate agencies and business firms. However, barring any major adverse developments in these areas, the Chinese government will probably have few incentives to expand its current level of missile-related exports for several reasons. First, U.S. opposition to state-sponsored transfers will remain very high, and hence the potential political and economic costs of engaging in such activities could outweigh the presumed gains. China will probably wish to avoid appearing to be a major supporter of what many regard as an important component of WMD proliferation. Second, China has arguably already supplied Pakistan—the major recipient of Chinese missile transfers—with what it needs to develop a credible deterrent against India, and further major assistance is probably unnecessary. Third, few if any other strategic imperatives exist for the time being that would likely prompt Beijing to undertake a policy of extensive missile transfers such as those provided to Pakistan. As noted above, China might have provided recent production assistance to Syria, but these reports remain unconfirmed.

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[78] Medeiros and Gill, *Chinese Arms Exports*; Kan, "China: Ballistic and Cruise Missiles"; Chapman, "PRC Military Weapons Sales."

[79] Waheguru Pal Singh Sidhu, "Regional Perspectives: South Asia," *International Perspectives on Missile Proliferation and Defenses, CNS Occasional Paper*, no. 5, p. 66.

Even if Beijing genuinely seeks to minimize or eliminate its missile transfers, however, it is almost certain that some level of Chinese missile assistance will be provided to foreign countries over the next 10–15 years. Beijing's ability to monitor and enforce restrictions on missile transfers will depend heavily on the ability and willingness of responsible central agencies and subordinate offices to supervise and implement existing and future regulations and procedures against both missile-related and dual-use items. Economic and political corruption, close relationships between manufacturers, customs agents, shippers, and customers, and the belief—held by some individuals—that missile transfers are no more dangerous than other forms of arms sales, will likely result in unauthorized sales of such items. Even if the amounts sold are relatively small, the effect on the missile development program of one or more foreign countries could be significant. Perhaps even more important, Beijing's willingness to restrain its missile transfers could easily fall prey to a deterioration in U.S.-China relations over Taiwan. Such a development could lead Beijing to renege on its commitments and undertake missile transfers, as a form of retribution against U.S. actions, or to develop political leverage of some sort.[80]

Hence, although the likelihood that Beijing will transfer complete missiles or extensive missile production technologies and equipment is not high, other types of less immediately significant or direct transfers could take place. And adverse shifts in the larger political environment could conceivably prompt China to resume significant missile transfers.

North Korea

North Korea has engaged in significant amounts and types of missile transfers since at least the 1980s. Major transfers include:

• The export of Scuds in large quantities to Egypt, Iran, Syria, Libya, and possibly Vietnam.[81] Several analysts believe that in the past, Iran was the primary financial supporter of North Korea's missile development program. The Iran-North Korea relationship dates from 1983 when Iran agreed to fund the reverse-engineering of the Scud-B missile in exchange for the option to purchase production models. Iran may have shared test data from its July 1998 launch of the Shahab-3 with North Korea.[82]

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[80] Medeiros and Gill, *Chinese Arms Exports*.
[81] Canadian Security Intelligence Service <www.csis-scrs.gc.ca>.
[82] Center for Nonproliferation Studies <http://cns.miis.edu>.

• The provision of assistance to Egypt in the development of an extended-range, 450 km Scud (the Project-T) that began production in 1990 and likely entered service in 1993. North Korea has provided both Scud assembly facilities and the means to develop the Project-T. In mid-1996, North Korea reportedly supplied Scud-C related material to Egypt, which would enable Cairo to begin Scud-C production, as well as Scud launcher vehicles.[83]

• The possible export of Nodong-1 missiles to Iran, Libya, Syria, and Pakistan.[84] Pakistan and Iran may have funded the Nodong and Taepodong programs in exchange for Nodong technology. Iran may be able to produce Nodongs within two years, and the Pakistani Ghauri is either a Nodong import or a technological derivative.[85]

• The provision of assistance to Syria to reverse-engineer and begin production of the Russian-made SS-21 SRBM, the missile designed by the Soviets in the 1970s to replace the 1950s vintage Free Rocket Over Ground (FROG) systems.[86]

As in the case of China, the scope and character of North Korea's missile transfers have changed considerably over time. Initial deliveries of North Korean missiles to customers in the Middle East in the 1980s consisted of complete missile systems. More recently, deliveries have often been in the form of missile components, "knock-down" kits, and associated production or assembly equipment (though some transfers to India and Pakistan have consisted of complete missiles). These changes will allow more rapid shipping deliveries and interception of such shipments will become more difficult. North Korea may currently be transferring equipment that will allow countries such as Iran and Pakistan to become indigenous producers of intermediate- and medium-range ballistic missiles. Moreover, as western resistance to the deliveries has increased, shipments have begun to be made by air rather than by sea, sometimes with the assistance of Russian private companies.[87]

North Korea may be transferring equipment that will allow Iran and Pakistan to become indigenous producers of intermediate- and medium-range ballistic missiles.

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[83] Center for Nonproliferation Studies <http://cns.miis.edu>.
[84] *Ibid.*
[85] *Ibid.*
[86] *Ibid.*
[87] *Ibid.*

North Korea's future involvement in missile transfers (including missiles, technology, technicians, TELs, and underground facility expertise) will depend on the efficacy of detection and control regimes, and on the evolution and outcome of discussions with the United States regarding its missile development program and related activities. A combination of U.S. pressure and positive economic and political developments could conceivably result in a significant decrease in North Korean proliferation activities. Alternatively, a breakdown in the U.S.-North Korean talks combined with a worsening of both Pyongyang's economic problems and the general political situation on the Korean Peninsula could produce a major increase in such activities. Regardless of which occurs, however, Pyongyang will probably at a minimum continue to engage in some types of missile-related imports and exports to generate much-needed income and to maintain political leverage. In particular, technical experts from Russia might provide various types of hard-to-detect "software" assistance, most likely without the consent of the Russian government. Assistance might also include transfers of small pieces of equipment. Moreover, North Korea will almost certainly maintain some level of missile-related contacts with Iran and perhaps Syria, and might attempt to expand its apparent contacts with Pakistan and even initiate transfers with other countries in Central and Southwest Asia. In other words, the range of North Korea's future missile transfers could conceivably cover a fairly broad spectrum, from a small amount of low-profile, largely technology-based imports to a fairly large amount of both technology and material exports, including possibly complete SRBMs, MRBMs, and IRBMs. Although possible, the transfer of ICBM technologies is deemed less likely by many experts over the next 10–15 years.

North Korea might expand its contacts with Pakistan and even initiate missile transfers with other countries in Central and Southwest Asia.

Pakistan

Although probably not currently a source of missile transfers, Pakistan will almost certainly continue to receive some ballistic missile-related technology and materials as part of its robust, ongoing SRBM and MRBM development programs. China and North Korea will be the most likely sources of such assistance, although other countries, such as Iran, could conceivably become involved as well. It is difficult to say at this point to what extent Pakistan will remain dependent upon outside assistance over the long term. As its indigenous capabilities grow, Islamabad's need for foreign technology and especially materials might diminish significantly. Arguably of greater concern to the international community is the issue of whether Pakistan will begin to export missile-related knowledge and equipment. Pakistan currently voluntarily accepts the guidelines of the MTCR and insists that it does not and will not export missile-related items. However, the possibility that the Pakistani government or non-state actors in Pakistan might engage in missile transfers for a combination of economic and political reasons cannot be ruled out.

South Korea

South Korea is not currently engaged in missile transfers. It adheres to the export conditions of the MTCR, although it has never formally joined the arrangement. However, South Korea reportedly plans to become a leader in Asia's aerospace industry by developing state-of-the-art SLVs and satellites. If these plans come to fruition, South Korean aerospace technology may become available on international markets, thus necessitating effective and responsible export controls. South Korea has been exemplary in controlling the spread of its missile technology because of its close military ties with the United States. Despite its past behavior, however, it may be difficult to assess the future direction of South Korea's export-control practices for missile technology.[88]

The Role of Ballistic Missiles in Force Structure, Strategy, and Doctrine

China

The general attitude of Chinese leaders toward the possession and use of ballistic missiles differs significantly from that of the leaders of the United States and other western countries. For the Chinese, ballistic missiles are not viewed solely as weapons of mass destruction but rather as highly versatile delivery systems for both WMD and conventional warheads. In some scenarios, they are treated as relatively cheap equivalents to more advanced and versatile delivery systems such as attack aircraft, or even as a type of very long-range artillery. For many Chinese, therefore, ballistic missiles can serve as either conventional

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[88] *Rumsfeld Report*, Appendix III: Unclassified Working Papers: System Planning Corporation: Non-Proliferation Issues—South Korea.

war-fighting instruments or as delivery systems for both conventional and WMD deterrence weapons, depending upon their range and the size and type of warhead employed.

China's relatively small MRBM, IRBM, and ICBM forces serve as the primary delivery system for China's nuclear arsenal. These systems were developed solely for deterrence purposes, to prevent nuclear blackmail or nuclear attack by holding at risk a small number of key population centers and major forward-deployed military assets (i.e., "counter-value" targets) of a more powerful, nuclear-armed adversary (i.e., the United States or Russia), and to caution other nuclear or proto-nuclear powers such as India against contemplating the threat or use of WMD against China. This capability constitutes a "limited, self-defense counterattack" force that can undertake small-scale nuclear retaliation at a time, and against targets, of Beijing's choosing. The resulting "minimum deterrence" doctrine generally assumes that China would absorb an initial nuclear attack rather than undertake a launch-under-attack (LUA) or a launch-on-warning (LOW). Perhaps most important, the effectiveness of this deterrence hinges on the inability of an adversary to destroy all of China's WMD capabilities, especially its strategic missile force, in a first strike.

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.

China has gradually sought to improve its increasingly obsolescent strategic arsenal and to increase its deterrence credibility in the face of what are viewed as increasing strategic and technological challenges from the United States and other major powers. This effort has led to the development of solid-fuel systems and road-mobility.[89] It has also resulted in the development of strategic submarines and SLBMs. With recent moves by the United States and Japan to develop missile defense systems, the requirements of China's modernization program have increased still further. To avoid being rendered completely ineffective by missile defenses

[89] In the past, the limited numbers, low level of readiness, and slow response times of China's land-based missiles and bombers left China vulnerable to an overwhelming and incapacitating first strike. China does not currently have space-based or land-based early warning assets. A senior U.S. intelligence official has confirmed that Chinese missiles are usually unfueled and unmated to their warheads. Furthermore, the process of loading the liquid fuel tanks and installing the warheads can take two to four hours. Gill and Mulvenon, "China and Weapons of Mass Destruction."

capable of neutralizing China's minimal deterrence force, Beijing has initiated (but apparently not yet deployed) MIRV and countermeasure technologies, and is probably increasing the number of its strategic missiles.[90]

SRBMs like the CSS-8 were meant to provide theater conventional war-fighting capabilities, as cheaper delivery vehicles than aircraft. Other SRBMs, like the original versions of the DF-11 and DF-15, were originally intended for export, in competition with Russian and North Korean Scuds. Such missile sales generated intense U.S. pressure, however, and the dispute with Taiwan created an arguably more urgent political-military demand for the missiles at home. Arrayed against Taiwan, these weapons have been used as instruments of coercive diplomacy. They have also become China's only counter to a theater attack from potential adversaries like the United States, which demonstrated the power of its missiles during the Gulf War and in Kosovo.[91] Some observers believe that the continued deployment of both short- and medium-range missiles, with both conventional and nuclear warheads, might lead Beijing to develop a more aggressive doctrine for theater warfare. Such a posture could threaten Taiwan, Japan, and U.S. troops in Okinawa, as well as act as a warning to the United States against nuclear escalation.[92]

For some observers, the combination of developments described above suggests a gradual movement from China's previous minimum deterrence strategic posture to a more versatile limited deterrence doctrine. This doctrine is centered on the deployment of sufficient counter-force and counter-value tactical, theater, and strategic missile forces to deter conventional, theater, and strategic nuclear conflicts and to control escalation and compel an adversary to back down if deterrence fails. However, such a force structure, much less the more sophisticated limited deterrence doctrine to support it, would require a wide variety of components, including high levels of warhead accuracy, a more diverse range of delivery systems in larger numbers, combat troops trained to utilize such systems, and more robust early warning, detection, surveillance, and targeting capabilities to identify the source of attacks and to locate and destroy military facilities and large conventional and WMD force concentrations. A capacity

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[90] According to Center for Defense International Security Studies, China has had MIRV technology since 1995. <www.cdiss/chinab.htm>.

[91] China's strategic nuclear missile arsenal does not constitute a credible deterrent against a conventional missile attack, since any threat to employ those few weapons would immediately escalate a limited, conventional attack to the far more dangerous nuclear realm, and thereby threaten national annihilation by the United States' vastly superior strategic arsenal.

[92] Federation of American Scientists <www.fas.org>.

for rapid response and the ability to concentrate firepower quickly and massively would be required to defeat enemy forces early and decisively. Although China is attempting to acquire at least some of these elements (e.g., greater warhead accuracy and a more proficient early warning and command, control, communications, and intelligence capability), others (e.g., combat troops trained to employ theater and tactical nuclear missiles) are nowhere in evidence. Overall, the Chinese do not at present possess the capacity to implement this vision, owing to economic, technical, organizational, and arms control restraints. Hence, the argument of some observers that China is actively engaged in developing an aggressive, war-fighting oriented, limited deterrence WMD-armed missile force and supporting doctrine, even at the theater level, is at the very least premature.

India

For the government of India, ballistic missiles serve as both potential war-fighting weapons (in the case of its SRBMs) and, more importantly, as a potential delivery system for nuclear (and perhaps chemical) weapons, as part of a strategic deterrence posture directed against Pakistan and China. The development of a nuclear-armed IRBM (and perhaps, eventually, ICBM) capability also undoubtedly serves an important status function, in support of India's long-standing quest for global or at least Asian great power stature. Moreover, India's missiles might become an export commodity that could both generate greatly needed income and break what Delhi regards as an unfair missile technology monopoly.[93]

The specific size, configuration, disposition, and possible deployment of India's strategic missile force are not entirely known at present, since the force is still in the early stages of development. However, India has declared that it will pursue a doctrine of minimum nuclear deterrence combined with a "no-first-use" approach to nuclear weapons. This doctrine—similar to that espoused by China—implies that India will likely develop a small, concealed counter-value force of strategic ballistic missiles capable of surviving a first strike and retaliating against the major cities of potential adversaries such as Pakistan and China.[94] This force will probably not have the capability to launch on warning or launch under attack, given strong U.S. opposition to such deployment modes, the technical limits of India's strategic warning

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[93] Cirincione, "Indian Missile Deployments and the Reaction from China."

[94] It is unclear whether India believes it will ultimately become necessary to develop long-range missiles systems to deter a possible attack by more distant nuclear-armed powers, such as the United States.

system, and, most importantly, the desire of India's civilian leadership to maintain strict control over any nuclear weapons. (The Indian military almost certainly will not be given operational control over nuclear-armed ballistic missiles.) Hence, India's missiles will likely be kept separate from their warheads. Furthermore, the use of ballistic missiles as retaliatory, counter-value weapons also suggests that their number need not be very large. The exact number will reflect Indian estimates of how many missiles are required both to survive a first strike by Pakistan or China and to wreak sufficient retaliatory damage to constitute a credible deterrent force. If China significantly increases the number of its MRBMs and IRBMs capable of striking India, perhaps in response to deployment by the United States or its allies of ballistic missile defense systems—or if China itself develops a ballistic missile defense system—India might then conceivably be pressured to increase the number of its MRBMs and IRBMs in response.

The structure and disposition of India's SRBM force will largely be determined by a more complex combination of factors, including estimates of: 1) the number and deployment configuration of conventionally-armed missiles required to support both a conventional conflict against Pakistan and/or possibly a limited border war with China; and 2) the number and deployment configuration of nuclear-armed missiles required to pose a credible nuclear deterrent against Pakistan. Although the Prithvi is considered nuclear-capable by some experts, it is possible that India will not utilize SRBMs as WMD vehicles to deter Pakistan against using or threatening the use of its nuclear weapons. Also, India's current decisive conventional superiority over China along their common border suggests that Delhi will probably not rely significantly on SRBMs to prosecute a future possible border war. The costs of such a large missile force are prohibitive, and the Indian Air Force does not have much confidence in the Prithvi. Such considerations might keep the number of deployed SRBMs at relatively low numbers. However, one cannot rule out the possibility that India will manufacture and perhaps deploy hundreds of SRBMs with its military units. As indicated above, there are already some indications that such deployments are underway. Such a development might derive more from status competition among India's armed services than from any clear military or strategic requirements.

There is no evidence at present that Delhi has authorized the transfer of ballistic missiles, missile components and equipment, or missile-related technology to any other country.

India has stated that it is opposed to missile proliferation, and there is no evidence at present that Delhi has authorized the transfer of ballistic missiles, missile components and equipment, or missile-related technology to any other country. Moreover, such transfers would undoubtedly provoke a strong response from the United States and other major powers, and thus greatly undermine India's efforts to improve relations with the United States and to raise its overall status in the world community. At the same time, India is not a member of the Nonproliferation Treaty, the Nuclear Suppliers Group, or the MTCR. Indeed, it is a long-standing critic of the MTCR, which it regards as a selective and discriminatory "technology denial regime." India favors a global, inclusive, non-discriminatory, and genuinely multilateral arrangement designed to prevent missile proliferation without obstructing the development of civilian space launch programs. In the absence of such an arrangement, India purportedly unilaterally enforces its own export control regulations. However, both economic incentives and the promotion of India's extremely active SLV program could conceivably precipitate authorized or, more likely, unauthorized missile transfers in the future.

North Korea

Pyongyang's ballistic missile program serves several apparent functions, including efforts to preserve the North Korean regime, provide political leverage, augment economic capabilities, and facilitate the reunification of the Korean Peninsula. North Korea's Scuds were originally intended as conventional war-fighting weapons for use against South Korea. In particular, they compensated for the North Korean air force's lack of a long-range strike capability. The longer-range Nodong was presumably developed in part to threaten U.S. forces based in Japan, as well as perhaps Tokyo, in order to deter both countries from providing support to South Korea in the event of a resumption of hostilities on the peninsula. However, the Nodong's relatively small payload capacity and low accuracy suggests that it would be useful only as either a random terror weapon when armed with conventional explosives or as a strategic deterrent when armed with a WMD warhead. It is not a counter-force weapon. The longer-range Taepodong could also serve such specific purposes. (Although the Taepodong might also be intended as an SLV. In fact, at least one source argues that the configuration of the missile suggests that it was designed primarily for space flight.[95] However, even if intended as a space vehicle, the Taepodong can almost certainly be modified to serve as an offensive ballistic missile.)

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[95] The Federation of American Scientists <www.fas.org> states: "The configuration of the missiles suggests that they were designed for use not as weapons, but simply for space flight. Furthermore, the inability of the launch infrastructure to support anything other than limited operations under non-winter weather conditions indicates that North Korea has not seriously contemplated deploying the Taep'o-dong as an offensive weapon system. This brings into serious question whether more has been read into this program that can be legitimately justified."

In addition to their presumed war-fighting or strategic deterrence purposes, North Korea's ballistic missiles were also in part created or subsequently enhanced to serve political and economic functions and as a means of supporting continued research and development for its overall nuclear, biological, and chemical weapon and missile programs. As indicated above, Scud-Bs and Scud-Cs have been sold throughout the Middle East and elsewhere. Pyongyang has probably either sold or is attempting to sell Nodongs or Nodong-related technologies, and perhaps even Taepodong-related technologies, to a few countries. It is also attempting to use the threat of ballistic missile developments and deployments to extract political concessions and/or economic assistance from the United States and Japan. Although Pyongyang agreed with Washington in October 2000 to place a moratorium on the test-launching of any type of long-range missile while talks on missiles continue, this arrangement could unravel as a result of increased political tensions on the peninsula and a growing confrontation between North Korea and the United States.

Pakistan

The primary purpose of Pakistan's ballistic missile force is to provide reliable delivery systems for nuclear (and perhaps chemical) warheads in order to deter an Indian conventional or WMD attack or to defeat India if deterrence fails. In addition, the transfer of ballistic missiles or missile-related technology could also serve in the future as an important source of foreign exchange or political influence, given Pakistan's serious economic problems, and especially if a radical Islamist government were to come to power in Islamabad.

Some experts believe that conventionally-armed SRBM and MRBM systems are primarily designed to augment Pakistan's extremely limited offensive air capabilities against India (which holds a nearly three-to-one advantage in combat aircraft) and to field a more effective delivery system.[96] However, the relatively small payload capacity, individual unit cost, and poor accuracy of Pakistan's existing and emerging SRBM and MRBM forces makes them a relatively inefficient and expensive means of delivering conventional explosives. With the possible exception of the Hatf-1, Pakistan's ballistic missile force is designed to deliver WMD warheads (thereby compensating for the inferior and deteriorating state of the Pakistani conventional armed forces) and hence will play an increasingly important role in Pakistan's deterrence strategy.

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[96] Gregory Koblentz, "Viewpoint: Theater Missile Defense and South Asia: A Volatile Mix," *Nonproliferation Review*, Spring–Summer 1997, p. 58, citing a Department of Defense report *Proliferation: Threat and Response*, Washington, DC, Government Printing Office, April 1996, p. 36.

As in the case of India, the specific size, configuration, disposition, and possible deployment of Pakistan's ballistic missile force are not entirely known at present, since the force is still in the initial stages of development. Moreover, again as in the case of India, Pakistan will almost certainly strive to deploy a small, counter-value, minimum deterrence-oriented strategic missile force. Some experts argue that fear of a decapitating first strike by India will eventually prompt Pakistan to deploy its future ballistic missile arsenal at a high state of readiness. However, a combination of U.S. pressure, confidence in India's inability to locate Pakistan's missiles, and a desire to maintain firm central control over all nuclear weapons and delivery systems may prevent such a deployment. As with India, Pakistan's strategic missile arsenal will probably have the capacity to deliver chemical, biological, and nuclear warheads.

South Korea

South Korea's small ballistic missile program is focused on developing SRBMs for both war-fighting and strategic purposes, to deter or, if necessary, defeat North Korea in a military conflict. The intended size and configuration of Seoul's SRBM force is unknown, but will likely derive from calculations of the number and deployment configuration of conventionally-armed missiles required to support a conventional conflict against North Korea. Some observers have speculated that South Korea might consider developing WMD warheads for delivery by its SRBM force, but there is no evidence of such a program. South Korea's robust SLV program could potentially support the development of longer-range ballistic missiles, but Seoul has denied this.

Taiwan

As indicated above, Taiwan might possess a BSRBM and is probably developing an SRBM, possibly with a range approaching that of an MRBM. These missiles are intended to deter China from attacking Taiwan or to support military action against China should deterrence fail. The specific purpose and targets of such missiles (and especially any missile approaching a 1,000 km range) are not entirely clear, however. Some Taiwanese leaders have at times supported the notion of developing offensive missiles as the pillar of a deterrent, second-strike capability. This notion would be in line with indications of growing support within the Taiwanese government for a more active and outward-oriented defense strategy in place of the existing purely defensive posture. This strategy reportedly emphasizes the conduct of warfare beyond Taiwan and the acquisition of capabilities to retaliate against targets such as Shanghai and Beijing.

There are two basic schools of thought on the sort of specific offensive capabilities Taiwan should acquire as the core of this strategy. The first argues that the acquisition of an offensive *counter-force* capability is necessary to deter China from launching a conventional attack against Taiwan, and, if deterrence fails, to significantly degrade China's ability to sustain such an attack against Taiwan. These forces would consist essentially of several hundred SRBMs and air assets capable of striking China's ports, theater C3I nodes, and missile launch sites. The second school of thought argues that Taiwan must focus on acquiring offensive strategic *counter-value* capabilities to threaten major Chinese cities in central and southern China, such as Shanghai, Nanjing, Guangzhou, and Hong Kong. These would consist essentially of a relatively small number of MRBMs with large conventional or perhaps even nuclear or biological warheads, intended purely as a deterrent against an all-out Chinese assault on Taiwan.

There are, however, many opponents to the acquisition of either type of offensive capability. These individuals point out that Taiwan could not develop a large enough offensive counter-force capability to credibly threaten the extensive number of potential military targets on the Chinese mainland. In particular, such missiles would likely have great difficulty locating and destroying China's large number of mobile SRBMs. Moreover, the use of offensive ballistic missiles by Taiwan could significantly escalate an unfolding conflict with China. An offensive counter-value capability would also be of very limited utility, opponents argue, because: 1) China likely would be undeterred if Taiwan could only threaten its central and southern cities and not Beijing; and 2) any type of credible counter-value capability would almost certainly require WMD warheads, which the United States would strongly oppose. In short, an offensive counter-value capability would likely prove to be inadequate and could greatly exacerbate U.S.-Taiwan relations. Even more important, it might also provoke a massive preemptive Chinese strike, or at the very least a massive Chinese counterstrike that would almost certainly devastate Taiwan.

Ballistic Missile Defense

The expansion of missile capabilities among several Asian states—and in particular North Korea and China—has stimulated interest in the region in the development and deployment of a variety of possible defensive countermeasures, most notably ballistic missile defense (BMD) systems. In October 1998, the U.S. Congress passed legislation requiring the Secretary of

Defense to conduct a study on the establishment and operation of a missile defense system in the Asia Pacific region to protect the United States' "key regional allies."[97]

According to many experts, given cost, suitability, and other considerations, the most likely type of BMD systems available to Asian states include four categories of TMD systems:[98]

- Land-based lower-tier, similar to Patriot PAC-3 Configuration Three.[99]
- Land-based upper-tier, similar to THAAD (Theater High Altitude Area Defense, with THAAD missile and TMD ground-based radar).[100]
- Sea-based upper-tier, similar to Navy Theater Wide (NTW) Phase One.[101]
- Sea-based upper-tier, similar to NTW Phase Two.

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[97] Center for Nonproliferation Studies < http://cns.miis.edu>.

[98] There are two main BMD architectures—national missile defense (NMD) and theater missile defense (TMD). A NMD system would be designed to protect civilian population centers on the homeland from being attacked by nuclear-armed ICBMs and SLBMs, whereas TMD is a deployed missile defense designed to protect forces and their allies on a (likely foreign) battlefield from theater ballistic missiles. For countries that border potential adversaries, TMD could also protect the homeland, essentially making it a NMD system. NMD or TMD systems require intelligence regarding the missile threat, early warning and close tracking and cueing capabilities, the ability to distinguish incoming warheads from decoys, an efficient battle management system, an integrated C3I infrastructure, and interceptors capable of homing in on fast-moving targets. Much of the following discussion of TMD systems is taken from Michael D. Swaine, Rachel M. Swanger, and Takashi Kawakami, *Japan and Ballistic Missile Defense*, RAND, 2001, pp. 25–29; and "Theater Missile Defenses in the Asia-Pacific Region," *Henry L. Stimson Center Working Group Report*, no. 34 (June 2000; hereafter referred to as the *Stimson Report*).

[99] Lower-tier systems are designed primarily to intercept SRBMs within the atmosphere, as well as cruise missiles and aircraft, utilizing relatively slow-flying interceptors that maneuver to their targets. They provide "point defense" for small areas.

[100] THAAD is a land-based upper-tier TMD system designed to shoot a hit-to-kill interceptor at incoming missiles during their terminal phase. THAAD would intercept an incoming missile hundreds of kilometers from the target, either high in the atmosphere or in space (with an approximate coverage of a 200 km radius and 150 km ceiling). Hit-to-kill interceptors are intended to home in on an incoming missile with an infrared seeker and strike it directly rather than destroying it with a proximity explosion. Upper-tier systems are designed to protect large areas when employed in conjunction with lower-tier point defense systems, i.e., as part of a "layered" BMD system. The upper-tier systems provide a wide umbrella designed to engage long-range missiles at a great distance from the target and in the upper stratosphere, while lower-tier systems protect smaller areas within the umbrella from short-range missiles and missiles that make it through the first layer of defense.

[101] The NTW operates like THAAD, but may also be used to engage incoming ballistic missiles during their boost and/or mid-course phases, when the ship can be positioned close to the missile's launch site. The system operates from enhanced versions of the AEGIS air and missile defense radar deployed on U.S. Ticonderoga-class cruisers and Arleigh Burke-class destroyers.

The PAC-3 Configuration Three land-based lower-tier system is designed to possess the radar ability to distinguish between genuine warheads and decoys or debris. It could possibly defend out to several tens of kilometers from the interceptor's launch point. The system has enjoyed several successful test intercepts over the past few years. Thus, it will likely possess a good chance of defense against North Korean-type Scuds with single warheads, although some experts doubt that it could reliably intercept Scuds that maneuver, tumble, or "corkscrew" upon reentry.[102] The THAAD system is designed to be highly mobile and to possess a "shoot-look-shoot" concept of operations.[103] However, thus far, THAAD has failed in the majority of its test intercept attempts.[104]

The sea-based upper-tier (i.e., NTW) system is based on the evolving capabilities of the AEGIS Weapons System (AWS) and SPY-1B/D radars, which are located on Ticonderoga-class (CGE47) guided missile cruisers and AEGIS-equipped (DDGE51) guided missile destroyers. The AWS (also known as the AEGIS Combat System—ACS) is currently deployed on 27 U.S. Navy Ticonderoga-class cruisers and 28 AEGIS-equipped destroyers, as well as 4 Japan Maritime Self-Defense Force (MSDF) Kongo-class destroyers. The NTW is designed to intercept MRBMs and IRBMs during ascent, along trajectory, or during descent using the SM-3 and the LEAP (Lightweight Exo-Atmospheric Projectile) kill vehicle and other new features beyond the existing SM-2 Block IV missile.[105]

The NTW system is not designed to intercept cruise missiles, aircraft, or SRBMs that do not leave the atmosphere for any significant period of time. The intercept ranges for the NTW will probably not exceed 1,200 km. However, given the right placement, a single NTW ship "…may be able to defend an area as large as 2,000 km in diameter against a 1,000 km range

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[102] James M. Lindsay and Michael E. O'Hanlon, *Defending America: The Case for Limited National Missile Defense*, Washington, DC: Brookings Institution Press, 2001, p. 183. See also Joseph Cirincione citing David Eshel (a retired officer in the Israeli Defense Force), who writes in *Jane's Intelligence Review*, "Although this system [the PAC-3] has an increased range and an onboard terminal radar guidance system it is doubtful that this could overcome the unique corkscrewing effect of the Iraqi Al-Hussayin Scud missile." Joseph Cirincione, "The Political and Strategic Imperatives of National Missile Defense," paper presented to the *Seventh ISODARCO Beijing Seminar on Arms Control*, Xi'an, October 8–12, 2000.

[103] Under THAAD's "shoot-look-shoot" system the range of the interceptor missile is such that one can be fired, an assessment made about whether it has hit the incoming ballistic missile, and, if necessary, a second interceptor launched.

[104] In 1999, the program achieved two successful test intercepts (after several failures) and consequently moved from the demonstration phase into the engineering and manufacturing development phase. *Stimson Report*, p. 7.

[105] *Stimson Report*, pp. 5–6, 8.

threat."[106] The NTW program is designed to obtain a near-term Block I capability against MRBMs in the ascent phase and a follow-on Block II capability against both MRBMs and IRBMs. The Block II variant will focus on defeating threats with ranges over 1,500 km. It will require an upgraded AWS, with a new High-Power Discriminating (HPD) radar, which could be an adjunct to or upgrade of the AEGIS SPY-1B/D radars. The variant also requires development of a single integrated air picture and coordination.[107] However, thus far the NTW LEAP kill vehicle has also failed several test intercept attempts.

Any developments in the area of missile defense within the region during the next 10–15 years will almost certainly take place primarily, if not solely, in Northeast Asia: particularly in Japan and Taiwan.[108] The development of robust (i.e., including both upper-tier and lower-tier) BMD systems by the United States would also profoundly impact the strategic environment in the Asia Pacific. The position of major countries in the region toward ballistic missile systems in Asia follows:

Chinese Views on Missile Defense

China is strongly opposed to the development and deployment of TMD systems in Japan and Taiwan. The Chinese position encompasses the following points:[109]

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[106] *Ibid*, p. 8.

[107] *Ibid*, p. 8.

[108] One cannot rule out the possibility that South Korea might seek to acquire a TMD system during this period, although the likelihood of this is not high. In fact, South Korean support for a U.S. TMD system in Korea (and even for a U.S. NMD system) might decline if a North-South peace agreement is concluded. See Green and Dalton, "Asian Reactions to U.S. Missile Defense," pp. 22–25.

[109] Some of the following points are drawn from the proceedings of the EANP U.S.-China 1999 Conference, available on the Center for Nonproliferation Studies website at <http://cns.miis.edu>. Others derive from private discussions with Chinese observers and a variety of secondary sources, including: Thomas J. Christensen, "Posing Problems Without Catching Up: China's Rise and Challenges for U.S. Security Policy," *International Security*, vol. 25, no. 4; Gu Guoliang, "TMD, NMD, and Arms Control," *Missile Defense Initiative Special Report*, no. 3 (October 2000); Hong Yuan, "The Implications of a TMD System in Japan to China's Security," *Nuclear Policy Project Special Report*, August 1999; Shinichi Ogawa, "TMD and Northeast Asian Security," *Missile Defense Initiative Special Report*, no. 2 (October 2000); *Stimson Report*; Patrick M. O'Donogue, *Theater Missile Defense in Japan: Implications for the U.S.-China-Japan Strategic Relationship*, Carlisle, PA: U.S. Army War College, September 2000; and Kori J. Urayama, "Chinese Perspectives on Theater Missile Defense: Policy Implications for Japan," *Asian Survey*, vol. 40, no. 4 (July/August 2000). We are also indebted to Iain Johnston and Michael McDevitt for providing their views on this issue in private correspondence.

• TMD could force China to greatly increase the size and sophistication of its IRBM missile arsenal, perhaps to include the use of MIRVed or MARVed[110] warheads and various countermeasures; accelerate its cruise missile and anti-satellite programs; and adopt a more robust limited nuclear deterrence doctrine oriented toward WMD war-fighting. Such an outcome would become even more likely if Taiwan were integrated into an East Asian BMD system that included Japan, South Korea, and the United States.

• TMD would undermine regional and global arms control efforts, retard nuclear arms control initiatives, reverse the process of reducing the number of MIRVed warheads in nuclear stockpiles, and generally weaken China's support for the CTBT, the MTCR, and the Fissile Material Cutoff Treaty (FMCT) negotiations.[111]

• The transfer of TMD-related technologies between Asia and Washington would almost certainly violate the MTCR, thus constituting a "double standard" in U.S. policy.

• TMD sales to Taiwan are an interference in China's internal affairs and constitute a violation of China's sovereignty and territorial integrity; they violate the 1982 U.S.-China communiqué and will seriously undermine U.S.-China relations.

• TMD sales to Taiwan will constitute a major step toward the creation of a de facto military alliance between the United States and Taiwan and will lead to an arms race across the Taiwan Strait; in particular, Taiwan could use TMD technologies to build offensive missiles.

• TMD will reduce China's ability to exert psychological leverage on Japan or Taiwan in a crisis by providing a plausible defense against the threat of a limited ballistic missile attack or other possible coercive threats contemplated by China.

• TMD, in the form of a Japanese controlled mobile NTW system, will provide Japan with the ability to protect Taiwan against Chinese ballistic missiles in a possible future military conflict, thereby reinforcing U.S. military intervention and facilitating Japan's independent efforts to establish influence over Taiwan.

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[110] MARVed warheads are those deployed on maneuverable reentry vehicles.

[111] Beijing criticized Washington's formal withdrawal from the ABM Treaty in December 2001, stating that the U.S. action could threaten world peace and spark a new arms race.

• TMD will encourage Japan to acquire offensive weapons systems (including possibly WMD capabilities) and in general fuel Japanese remilitarization by both stimulating the development of an offensive missile capability and providing a "shield" against China's nuclear deterrent; this might encourage Japan to develop the "sword" of nuclear weapons.

• TMD, in tandem with the strengthening of the U.S.-Japan security guidelines, will greatly deepen Japan's integration into a U.S.-based regional military C3I structure, encourage Japan's overall dependence upon the U.S. military system, and thereby facilitate the emergence of a joint U.S.-Japan-led "mini-NATO" in Asia intended to contain China.

Some of these points are probably true, while many have been exaggerated or created to deter the deployment of systems that would presumably weaken Chinese interests in Northeast Asia. Yet all should be taken seriously as forming the perceptual basis for potentially adverse Chinese reactions to BMD deployments.

At the same time, despite its objections to TMD in Japan and Taiwan, Beijing is engaged in the deployment of lower-tier "point defense" anti-missile systems as a means of protecting small areas of China from missile attacks. It has purchased S-300 (NATO designation: SA-10) SAM systems which have an inherent anti-missile capability from Russia. China might also be developing its own lower-tier TMD system.[112]

Japanese Views on Missile Defense[113]

Japan is receptive to the possibility of acquiring a BMD system. However, progress to date has been extremely limited, and the level of support for BMD heavily influenced by the government's bureaucratic and budgetary processes, U.S. pressure, and specific actions taken

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[112] In addition to opposing various types of TMD systems in Northeast Asia, China is also opposed to a U.S.-based NMD system. It believes such a system would weaken the credibility and effectiveness of its small strategic nuclear deterrent force, potentially exposing China to nuclear blackmail and/or a devastating first-strike. This is viewed as especially likely in combination with a U.S.-led TMD system in Asia and in the context of a crisis over Taiwan. Many Chinese consider the stated twofold purpose of a U.S. NMD system—to defend against either a small-scale missile attack by a "rogue state" such as North Korea or Iran or an accidental launching by a nuclear power—to be misleading. China does not believe that North Korea and Iran will acquire credible long-range ballistic missile capabilities in the foreseeable future and considers U.S. retaliatory capabilities to be sufficient to deter these nations from launching an attack. Moreover, Beijing deems the likelihood of an accidental launch to be extremely low.

[113] The following discussion draws from Swaine et al, *Japan and Ballistic Missile Defense*, pp. ix–xx.

by North Korea. Pyongyang's launch of a Taepodong-1 in August 1998 spurred Japan in late 1998 and early 1999 to move forward with joint research and development with the United States on ballistic missile defense. But the decisions taken thus far commit Japan only to limited participation with the United States on collaborative research and prototype production of a very small number of TMD components. Although Japan has acquired elements of a future lower-tier, land-based TMD system (in the form of the advanced PAC-2 system), it has thus far undertaken no effort to develop or acquire a dedicated BMD system of any type; nor has it assessed in any thorough or systematic manner the larger political and strategic implications of a Japanese BMD system. More important, no public or elite consensus has yet emerged in favor of the development or deployment of a full-fledged, integrated BMD system in Japan (including both upper- and lower-tier components and an integrated BM/C3 infrastructure). This lack of consensus reflects a variety of concerns:

- Maintaining the U.S.-Japan alliance—For Tokyo, BMD has the potential to strengthen or weaken the U.S.-Japan alliance by affecting bilateral trust and cooperation concerning such issues as the reliability of the U.S. deterrence, technology, cost, intelligence sharing, and the interoperability of U.S. and Japanese forces. Such uncertainties are a major factor underlying Japan's cautious approach to BMD.

- Financial constraints—Cost plays an important role in Japan's consideration of BMD. Three aspects are of particular importance: 1) the overall affordability of a fully-deployed system; 2) the potential financial impact of deployment of BMD on existing military programs; and 3) the potential impact of deployment on the budgets of the individual armed services.

- Legal considerations—Four legal concerns influence Japanese decision-making regarding BMD: 1) constitutional prohibitions against participation in collective defense efforts; 2) legislative resolutions prohibiting the military use of outer space; 3) laws against the export of weapons and military-related technologies; and 4) the provisions of the ABM Treaty.

- Technical/military feasibility and architecture issues—The technical feasibility of BMD systems and the type of BMD architecture required to meet the conceivable ballistic missile threats confronting Japan remain a subject of considerable debate. Many Japanese observers are highly skeptical about the basic concept of TMD; in particular, some doubt that the types of systems and architectures under consideration by Tokyo could provide adequate defense against the range of threats confronting Japan, especially those emanating from China.

• Industrial and commercial considerations—Japanese participation in BMD could provide enormous potential benefits to Japan's defense industry and industrial base. This creates a possible convergence of interests between the industrial offices of the Japan Defense Agency (JDA), certain divisions within the major defense contractors, and the Ministry of Economy, Trade, and Industry (METI). But overall, BMD is not viewed as an area that will generate major benefits in technology development for both military and related non-military industry and commerce. Unlike the case with the joint U.S.-Japan FSX (F-2) fighter aircraft project or with the development of surveillance satellites, no strong coalition of pro-BMD "techno-nationalists" exists within the Japanese government to promote BMD acquisition.

China's missile threat is the major factor compelling Japan to acquire a robust BMD system, according to many observers.

• The China factor—Significant controversy exists within Japan over how much consideration should be given to Chinese objections to BMD and to the overall ballistic missile threat posed by China and over the preferred Japanese response to these factors. Japan's political community in particular is highly divided over the nature and significance of the China factor in Japanese policy towards BMD. Within the Japanese security community many observers cite China's missile threat as the major factor compelling Japan to acquire a robust BMD system.[114] In contrast, others, including politicians and some officials, downplay the ballistic missile threat from China, arguing that Japan must avoid acquiring a BMD system capable of intercepting Chinese missiles in order to maintain good relations with Beijing and to increase the overall independence and flexibility of Japanese foreign policy.[115] A third group argues that the potential deployment of a BMD system could be used as a "card" to be traded away in return for concrete Chinese concessions on important security issues.

As a result of the above issues and concerns, Japan and the United States have not yet clarified 1) how essential it is for Japan to participate in a more extensive program of joint

[114] Japanese strategists are concerned that China might resort to using missiles to threaten or attack U.S. forces in Japan or even Japanese territory and citizens in two conceivable contexts: 1) as part of an escalating crisis over Taiwan; or 2) over the long term in support of efforts by a stronger and more confident China to achieve specific territorial, political, or strategic objectives in the Asia Pacific, such as control of the disputed Senkaku Islands claimed by both Beijing and Tokyo.

[115] Such individuals believe that the close involvement of Japan with the United States in the acquisition of a BMD system would make Tokyo excessively dependent upon Washington and thereby constrain Japan's options in handling security relations with China, North Korea, and other countries in Asia.

research and development; 2) the extent of system interoperability that is desirable and achievable for any future Japanese BMD system;[116] and 3) the impact of a decision to deploy on the strategic environment in Asia.

Absent major external precipitants or shifts (such as a crisis involving North Korea or China or a major increase in U.S. pressure), the emergence of strong, decisive leadership (along with a significant improvement in Japan's economic situation), or the availability of a workable TMD system, Japan is likely to continue its incremental approach to BMD research and funding for several years and to resist entering the development and deployment phases.[117] The pace of such limited research efforts will largely depend on commercial and technology transfer considerations and the level of government funding available, as well as Japanese perceptions of the success or failure of efforts to improve relations with North Korea. Moreover, without a formal government decision to proceed beyond the research stage, Japanese commercial and technological interests will likely receive few incentives to greatly accelerate or deepen the research program.

According to knowledgeable observers, a formal decision to move into the development and deployment stages could occur within four or five years in response to the likely introduction by the Japanese Air Self-Defense Force (ASDF) of an advanced C3 system for air and missile defense.[118] In other words, milestones anticipated by BMD-related C3 infrastructure improvements could force a basic decision on overall BMD architecture during this time frame.[119] However, the actions of the United States could also significantly affect a Japanese decision to move into development and deployment. For example, technological problems with the testing of the U.S. NTW system have reportedly raised the possibility that Japan will delay a development/deployment decision until at least 2008.[120] Any formal decision over

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[116] In particular, some Japanese are worried that a U.S.-Japan TMD system might be used to support the larger U.S. NMD system. This would presumably violate Japan's prohibition on involvement in collective defense and could drag Japan into a political-military crisis with a potential U.S. adversary.

[117] The following discussion is taken from Swaine et al., *Japan and Ballistic Missile Defense,* pp. xvii–xix.

[118] Green and Dalton ("Asian Reactions to Missile Defense," p. 15) state, without giving a reason for their assessment, that "a decision on NTW procurement and deployment is expected to take place by 2005."

[119] It is also possible that the ASDF might decide to upgrade its C3 infrastructure without making an explicit statement on the development phase of the BMD effort.

[120] See "Japan and U.S. Seen Extending TMD Study to '07," *The Japan Times,* December 20, 2001. This story describes the U.S.-Japan research program on naval-based TMD systems as "foundering."

whether to enter the development phase will likely involve a major debate, within which the questions of the creation of a joint U.S.-Japan C3 system and the level of Japanese versus U.S. control over long-range surveillance and cueing capabilities will arguably pose especially significant challenges.

At the same time, it is also possible—even likely—that various components of a BMD architecture, such as the PAC-3 system, additional AEGIS ships, and certain C3 and radar tracking infrastructure elements, will be acquired by Japan's self-defense forces as necessary and planned "upgrades" of existing systems, without any debate or formal decision on BMD per se. In other words, while avoiding an explicit decision to develop and deploy a BMD system, Japan could gradually acquire many of the elements of such a system.[121] Moreover, financial considerations will probably not obstruct such selective acquisitions, given the likely ability of the Japanese government to embed such costs in existing program budgets or to utilize off-line or special allocations.

At some point, however, a basic decision on the construction of a more complete and integrated BMD architecture will almost certainly need to be taken. A full-fledged lower-tier and upper-tier BMD architecture will probably consist of a mix of PAC-3 lower-tier and NTW upper-tier systems, supported by a more integrated and extensive Japanese early warning and BM/C3 infrastructure. Land scarcity and bureaucratic restrictions virtually preclude the acquisition by Japan of THAAD, according to many Japanese observers. It is likely that many of the elements of a Japanese BMD system will be built on existing foundations in the Patriot, the MSDF's AEGIS ships, and the ongoing improvement of the ASDF C3 and individual radar tracking systems. At the same time, most experts believe that any BMD system developed by Japan will have a very limited utility—especially against Chinese or Russian missiles—without the addition of an integrated U.S.-Japan early warning/C3 system.

Japanese citizens likely would not accept a situation in which Japanese living in areas close to U.S. bases would be protected by a U.S. BMD system, while others would not.

Japan will probably need to make a basic decision on the development and deployment of a combined lower-tier and upper-tier BMD architecture between 2007 and 2010 at the latest, in response to the likely emergence and deployment by that time of a workable, largely

[121] For example, many Japanese observers believe that the ASDF will eventually acquire PAC-3, regardless of whether a larger policy decision on BMD is made.

U.S.-produced NTW system. If the United States deploys such a system with U.S. forces in Japan, the pressure for Japan to adopt a nationwide BMD system will become enormous. (Japanese citizens likely would not accept a situation in which some segments of the population, living in areas close to U.S. bases, would be protected while other segments would not.) However, given the long list of military acquisitions already in the pipeline, the restricted size of Japan's defense budget, and the long period of time required to procure, deploy, and operationalize an integrated BMD architecture, Japan is unlikely to field a full-blown BMD system before 2015, even if a decision to deploy is made by the end of this decade.[122]

North Korean Views on Missile Defense

It is no surprise that North Korea is strongly opposed to the development and deployment of TMD in East Asia, especially in South Korea, and is also opposed to any U.S. effort to develop a NMD system. Such systems could conceivably neutralize Pyongyang's ability to threaten both Japan and U.S. military assets (and population centers) in the event of a crisis. Thus North Korea has denounced both discussions between South Korea and other countries regarding the acquisition of BMD systems and all tests of the U.S. NMD system. Pyongyang claims that South Korea is pursuing TMD as part of a general arms buildup in preparation for aggression toward the North.[123]

South Korean Views on Missile Defense

South Korea supports the deployment of a BMD system to defend its strategic interests vis-à-vis the North, although it has remained silent on the issue of TMD elsewhere in Asia and NMD in the United States. After some hesitation, Seoul eventually approved of the U.S. government's decision to deploy PAC-2 batteries in South Korea to protect U.S. forces, and would likely support the acquisition by the United States of PAC-3 systems in the future. Moreover, as indicated above, Seoul in the past has considered acquiring Russian, U.S., and Israeli air defense systems with limited BMD capabilities. However, the North Korean ballistic missile threat has confronted South Korea for many years, and is not a compelling threat compared to South Korea's other security concerns, such as an artillery attack by North

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[122] Some knowledgeable Japanese observers believe that a complete BMD system might not be fielded by Japan for as long as 20–25 years, especially if additional delays occur in the U.S. development of both PAC-3 and NTW systems.

[123] Center for Nonproliferation Studies <http://cns.miis.edu>.

Korea on Seoul. In addition, South Korea's economic downturn of the late 1990s has placed increased financial restraints on the government's ability to research, develop, and/or acquire BMD systems. Therefore, South Korea at present does not place a high priority on acquiring TMD systems to defend against the existing missile threat. In fact, it formally announced in March 1999 that it would not participate in the U.S. upper-tier TMD program. Moreover, Seoul correctly assumes that the United States would deploy additional, upgraded Patriot lower-tier TMD systems to the Korean Peninsula in a crisis to help protect both U.S. and South Korean sites essential to military operations.[124]

Taiwanese Views on Missile Defense

Taiwan supports the development and deployment of a lower-tier TMD system, despite recent indications of slow movement in this direction, and probably favors the eventual acquisition of an upper-tier capability as well, even though some observers harbor serious doubts about the latter's cost, feasibility, and likely provocative affect on Chinese behavior. Taipei has already acquired Patriot (PAC-2) missile systems from the United States and has received U.S. approval to acquire many elements of the PAC-3 system. In addition, the U.S. Congress has introduced legislation proposing strengthened U.S.-Taiwan TMD cooperation. Taiwan has also developed and is deploying two indigenous TMD-capable systems—the Tien Kung-1 and -2 SAMs. These are radar-guided, able to track objects up to 200 and 300 km respectively, and described by Taiwanese defense officials as equivalent to the U.S. Patriot air-defense missile. In addition to these two systems, Taiwan is also reportedly developing a more advanced, dedicated lower-tier, anti-tactical ballistic missile (ATBM) system to augment a future U.S. PAC-3 system.[125] Finally, Taiwan is reportedly developing an early-warning radar system to support these systems and is considering acquiring a long-range radar from the United States.[126]

Taipei has three primary motivations for seeking to acquire TMD systems. First, the upgraded Patriot system (PAC-3) and BMD-equipped AEGIS ships would provide Taiwan with a limited but significant capability against China's ballistic missiles, thereby contributing to the overall effort to deter Beijing from employing force. Second, the deployment of TMD systems would provide psychological reassurance to the people of Taiwan. Passive defense

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[124] *Stimson Report*, p. vi.
[125] "Locally Developed Missile Defense Considered," Agence France-Presse (AFP), December 17, 2001.
[126] Center for Nonproliferation Studies <http://cns.miis.edu>.

measures alone (such as the hardening of possible targets and various civil defense efforts) would not provide the same degree of reassurance as would the purchase of TMD systems from the United States. Third, and more important than the military dimensions of TMD acquisitions, Taipei has strong political motives to acquire a U.S.-manufactured TMD system. Indeed, many experts believe that the acquisition of TMD, from Taipei's perspective, has less to do with addressing the threat posed by China's ballistic missiles than with providing tangible evidence of U.S. support for the defense of Taiwan, and especially closer U.S.-Taiwan defense relations.[127]

At the same time, as a recent report on ballistic missile defense in Asia by the Stimson Center states, there has been little public debate in Taiwan (until recently) about whether TMD should be sought from the United States, what priority should be attached to acquiring TMD systems, and which systems should be purchased. It has been difficult for politicians in Taiwan to speak out against acquiring a system that may be capable of protecting Taiwan from China's missiles—even if the specific system happens to be a poor fit for Taiwan.[128] Nonetheless, doubts remain about various aspects of TMD systems. Taiwanese politicians remain sensitive to possible Chinese reactions to the acquisition of TMD systems by Taiwan, especially upper-tier versions. Members of the legislature regularly question the cost and utility of expensive and vulnerable early warning radars and lower-tier systems, although few understand the technical and financial aspects of the issue. Among some in the elite, lower- and especially upper-tier systems are regarded as unproven, provocative, and expensive. Moreover, while most military officers support the idea of missile defense on a political or psychological level, many are extremely skeptical of the military effectiveness of the proposed systems, for several reasons. First, missile defense in Taiwan faces greater operational challenges and must meet higher expectations than counterpart systems in the United States or Japan, considering the size, sophistication, and proximity of the Chinese ballistic missile force. Second, there is widespread concern that the announcement of the sale by the U.S. of upper-tier systems to Taiwan could provoke Beijing to launch a preemptive strike. Third, many military officers are wary of the costs of missile defense and worry that the systems will decimate their already insufficient

Taiwan's politicians find it difficult to speak out against a TMD system that may protect Taiwan from China's missiles—even if the specific system happens to be a poor fit for Taiwan.

[127] *Stimson Report*, p. vii.
[128] *Ibid*, p. xi.

procurement budgets. For this reason, many officers want Taiwan to put greater efforts into developing less expensive indigenous TMD systems. The indigenous ATBM system mentioned above could eventually supplant a planned PAC-3 system in parts of Taiwan.[129]

Among the armed services, the Taiwanese navy is clearly the most supportive of TMD and potentially has the most to gain. The naval platform of choice is the ACS/AEGIS-equipped destroyer. The acquisition of several of these platforms would significantly enhance the navy's stature and capabilities. However, even the strongest supporters of TMD in the navy recognize that the costs of such a purchase, which would likely be more than $1 billion per ship, would cause enormous interservice rivalry and opposition. As a result, its supporters describe the ACS/AEGIS program as a "national" system, while the navy's top priority continues to be the acquisition of 8 to 12 diesel-powered submarines, recently approved by the United States. The least supportive service branch is the army, which views missile defense as outside its primary mission: defending Taiwan's coast from massed Chinese attack. The army controls Taiwan's existing Patriot air-defense batteries and hence has agreed to support the acquisition of some aspects of the PAC-3 system, and possibly even the THAAD system. It also desires to control the C3I infrastructure associated with the systems, although other services have a stronger claim on this component. However, the army remains concerned about the overall cost and feasibility of TMD. Army officials are especially concerned that the high costs of PAC-3, AEGIS, and various early warning radars under consideration will require deep personnel cuts, which would disproportionately affect the ground forces and also prevent the acquisition of more conventional weapons favored by the army, such as heavy battle tanks. The air force exhibits strong support for missile defense, primarily for political and psychological reasons, and recognizes that the missile defense architecture will directly benefit its air defense effort. More important, the air force will be the primary beneficiary of upgrades to Taiwan's sensor networks, early warning capabilities, and C3I infrastructure, as well as the expected passive hardening of airfields around the country.[130]

Political considerations are extremely important in Taipei's calculus on BMD. The top priorities of the government are: 1) to reassure the public; 2) to maintain positive relations with the United States; and 3) to minimize the potential Chinese reaction to the acquisition of any BMD system. The level of support for TMD within Taiwan is also heavily influenced by bu-

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[129] Michael D. Swaine and James Mulvenon, *Taiwan's Foreign and Defense Policies: Features and Determinants*, RAND Center for Asia-Pacific Policy, Santa Monica, 2001, pp. 61–67.

[130] Swaine and Mulvenon, *Taiwan's Foreign and Defense Policies*, pp. 67–68.

reaucratic and budgetary issues. At present, Taipei is not moving to acquire those elements of the PAC-3 system that have already been approved for sale by the United States; nor is it showing much enthusiasm for acquiring critical support elements such as a more advanced, long-range radar. This is most likely due to a combination of interservice rivalries, budgetary and feasibility concerns, and an increased emphasis on the development of an indigenous lower-tier BMD system. The acquisition of any upper-tier systems continues to face major political and budgetary obstacles. Even if the United States were to approve the provision of such systems to Taiwan, it is unclear at this point whether Taipei would be willing and able to follow through. Another consideration is that the timeline for the full deployment of key systems is very long, even 10 to 20 years for limited coverage systems. This reduces Taiwan's incentive to operationalize (if not to acquire) such systems. Finally, the systems integration requirements are enormous, with reforms of air defense and C3I posing the most vexing challenges.

Taipei's first political priority for BMD is to reassure the public.

In terms of future trajectories, Taiwan will probably eventually seek to acquire lower-tier interceptors, as well as both lower- and upper-tier early warning systems and C3I infrastructure.[131] The primary focus will be on land-based systems, unless the United States approves the sale of ACS/AEGIS. To this end, Taiwan will likely seek to acquire key elements for joint early-warning radars, sensors, and C3I components. Taiwan will probably avoid any open advocacy of U.S.-Taiwanese integration in missile defense, but nonetheless favor closer ties, particularly in the broader military-to-military realm. Taipei also will likely seek to delay decisions on acquiring upper-tier BMD systems, avoiding public statements on the issue, and will likely avoid research and development cooperation on upper-tier. Taiwan instead will continue to "hedge" and proceed with the development of an offensive tactical missile. If the ACS/AEGIS is approved, Taiwan will likely acquire this platform and will probably also press Washington to equip it with the NTW BMD system, if the latter is shown to be effective. However, the specific architecture of any BMD system developed for Taiwan will be heavily influenced by U.S. calculations arising from the larger military and political environment affecting U.S-Taiwan-China relations. The United States could exert influence over future Taiwanese systems in at least three different ways.

[131] The following paragraphs are drawn largely from Swaine and Mulvernon, *Taiwan's Foreign and Defense Policies*, pp. 166–67, 169–70.

First, Washington could sell or transfer TMD systems directly to Taiwan. These systems could be either land-based systems (PAC-3 and/or THAAD) and/or sea-based systems (NTW). The land-based systems would likely require the construction of radar installations and missile batteries around Taiwan's major cities and military facilities. A Pentagon study on theoretical TMD architectures concluded that Taiwan would need at least 12 lower-tier land-based batteries for full coverage of the island, though this could be a mixture of Patriot systems and indigenous advanced Tien Kung-2 batteries.[132] The sea-based system would require the transfer of AEGIS combat systems to Taiwan, integrated on Taiwanese ships. Together, these systems (either alone or in combination) would surpass the existing Patriot batteries (PAC-2) to provide a layered upper- and lower-tier defense. There are two main obstacles to this option. First, the United States must agree to sell the systems over Beijing's objections. Although the sale of a full PAC-3 system (including interceptors) might not produce a major crisis with Beijing, the decision to provide an AEGIS-based NTW system likely would. At the same time, Taiwan, along with its supporters in the United States, would strongly oppose any attempt by Washington to avoid such a crisis by reaching a prior "understanding" with Beijing designed to limit both TMD and missile deployments. Such an understanding would likely be viewed as a violation of a U.S. assurance, provided to Taiwan in 1982, that Washington would not consult with Beijing before providing defense assistance to Taiwan. Second, such a system would require unprecedented levels of systems integration among the Taiwanese armed services, as well as extensive C3I modernization.

Second, the U.S. navy could deploy NTW systems on its own ships, which could then be sent to waters surrounding Taiwan during a crisis. This option has one major drawback and one major advantage over Taiwan-based systems. The drawback is that the ships would require a certain period of time to reach the theater, during which Taiwan would be highly vulnerable to a Chinese missile attack. The advantage of a U.S.-based system is that Washington would retain an element of control over both Taiwanese behavior and the level of escalation in a crisis. For example, the United States could conceivably blunt or deter provocative Taiwanese behavior by refusing to deploy TMD-capable ships during a crisis. On

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[132] *Report to Congress on Theater Missile Defense Architecture Options for the Asia-Pacific Region*, U.S. Department of Defense (hereafter referred to as Department of Defense, *Theater Missile Defense Architecture Options*).

the other hand, it is open to question whether the U.S. government, under pressure from Congress to defend Taiwan, could credibly exert such pressure, even if it were judged that Taiwan had instigated the crisis.

Third, the United States could transfer only the TMD early-warning apparatus to Taiwan while upgrading Taiwan's C3I infrastructure through military-to-military exchanges. This option could arise out of a bargain in which the United States promises China that it will not sell Taiwan either land- or sea-based upper-tier systems, but might transfer AEGIS combat systems to improve Taiwanese naval war-fighting and air defense capabilities to ameliorate Taiwanese security concerns. In the case of a crisis, Taiwan's early-warning capability might be useful to U.S. forces deploying to the region, serving as a forward radar picket for U.S. NTW ships.[133] At the same time, as indicated above, such an arrangement would be difficult to implement because Taiwan would strongly object to any such U.S.-China "bargain," while China could argue that the United States was recreating the U.S.-Taiwan defense alliance in all but name.

Finally, Taiwan is apparently attempting to indigenously develop a missile defense capability to augment, if not replace, the PAC-3 lower-tier TMD system. The Chungshan Institute is reportedly working on a missile defense variant of the Tien Kung-2 SAM system (the ATBM), with mixed success to date. According to Taiwanese interlocutors, this system will take eight years to equal PAC-3 level capabilities. Given limitations on Taiwan's indigenous development capabilities and an apparent preference for symbolic acquisitions from the United States, this option will almost certainly not replace the PAC-3 and NTW systems. However, it could eventually be deployed in sufficient numbers to reduce the cost of a PAC-3 acquisition.

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[133] This third option might prove to be a logical, albeit counterintuitive, strategy for Taiwan's leaders. Under this strategy, Taiwan would demur on the actual procurement of missile defense batteries, but work hard to advance its C3I, long-range radars, sensors, and tracking capabilities. The overall goal would be an alliance with the United States, not a full Taiwan-based layered TMD system. In other words, Taiwan would seek a TMD system under U.S. control, with the United States directly controlling certain information sensors in Taiwan. Those data links would bring the alliance closer together, with Taiwan serving as a "quiet partner." Underpinning this strategy would be a Taiwanese calculation that, whereas the United States might not move quickly to defend a Taiwan that had acquired its own limited missile defense infrastructure, it would almost certainly move rapidly to defend the island if it only possessed low-profile, non-provocative early-warning and C3I systems.

Implications for Asian Stability and U.S. Interests

Ballistic missile development in Northeast and South Asia has significant implications for the Asian security environment and U.S. political-military interests, both at present and over the next 10–15 years. The most important dimensions of regional security affected by missile-related developments include: 1) regional security relationships among key powers; 2) the proliferation of missile-related items within and beyond the region; and 3) direct threats to U.S. forces in the region and U.S. territory.

Regional Security Relationships

The continued development of ballistic missiles in Asia arguably could increase the chances of conflict in two sub-regions of great interest to the United States: 1) in Northeast Asia, between China and Taiwan and between North Korea and both South Korea and Japan; and 2) in South Asia, between India and Pakistan. Both of these sub-regions are critical strategic areas, containing high concentrations of military forces (including, in the case of Northeast Asia, U.S. forward-deployed forces with region-wide missions), key U.S. allies and friends, and major powers in tense political-military bilateral relationships. Instability or conflict in these sub-regions would affect the entire Asia Pacific.

Taiwan-China: The ongoing deployment by China of relatively large numbers of increasingly accurate, conventionally-armed SRBMs opposite Taiwan could increase significantly China's willingness to use force against Taiwan. In particular, the Chinese leadership might calculate that a large number of conventional ballistic missile strikes—when combined with aircraft and cruise missile attacks—could destroy many of Taiwan's critical military assets and terrorize the population, thereby allowing China to seize the battlefield initiative and establish the conditions for victory in a future confrontation over the island.[134] Such an action would obviously greatly undermine, if not destroy entirely, U.S. efforts to resolve the Taiwan issue peacefully. The presence of significant BMD systems could conceivably help to deter

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[134] Christensen, "Posing Problems Without Catching Up," p. 26. As Christensen states, some Chinese military strategists believe that "…using improved capabilities, a higher level of morale and resolve than the enemy, careful targeting, and innovative methods of early strike, China might be able to use accurate missiles to fight and prevail politically in a regional war over issues related to Chinese sovereignty, such as Taiwan."

China from embarking on such a dangerous course by reducing Beijing's confidence in the success of any ballistic missile-centered attack. On the other hand, the provision of a relatively robust, two-tiered BMD system to Taipei might actually destabilize the Taiwan situation by: 1) emboldening some Taiwan leaders to move toward more formal or explicit levels of independence in the mistaken belief that such a system could not only protect Taiwan against significant damage in the event of a Chinese attack but also guarantee a quick and effective U.S. response; and 2) provoking the Chinese leadership to coerce or strike Taiwan before such a system could be fully deployed. It is imperative that U.S. officials carefully assess not only the military aspects of providing various levels and types of ballistic missile defense systems to Taiwan, but the larger political and strategic consequences as well.

North Korea-South Korea: The continued deployment by Pyongyang of both Scud-C and Nodong-1 missiles gives it the capability of striking South Korea's rear areas and U.S. staging areas around Pusan. This is a capability that North Korea did not have during the 1950–53 Korean War, and that could influence substantially the course of a future conflict on the Korean Peninsula. This development could thus complicate U.S.-South Korean military planning.[135] At the same time, the provision of a U.S.-designed TMD system to South Korea might actually degrade Seoul's overall military capabilities by diverting limited defense resources into a costly system that will likely be provided by the United States in any event, and one that is designed to protect against a relatively small threat, compared to the conventional and WMD threat posed by Pyongyang's artillery. The acquisition by South Korea of a robust TMD system would make better sense if: 1) the United States did not intend to provide mobile TMD systems to protect U.S. and South Korean forces in the South; 2) Pyongyang relied more heavily on ballistic missiles than on long-range artillery; and 3) Pyongyang could deliver WMD warheads only via ballistic missiles, and not via artillery and other means, as is the case.

North Korea-Japan: The deployment by Pyongyang of large numbers of MRBMs and IRBMs capable of striking Japan with both conventional and chemical or biological warheads—especially if combined with a deterioration in political relations on the Korean Peninsula—would increase the threat confronting the United States' most important ally in Asia and would thereby complicate significantly U.S.-Japanese efforts to defend Japan in a crisis involving Pyongyang. (Other long-range missiles now in the design stage, such as the Taepodong-2, could potentially allow North Korea to threaten the entire western Pacific region.) Such a

[135] Center for Nonproliferation Studies <http://cns.miis.edu>.

threat could also intensify Japanese security anxieties and thereby conceivably increase support within Japan for significant shifts in defense policies. Such shifts might include a decision to acquire a robust BMD capability, most likely centered on the NTW system. Such a move would almost certainly increase Chinese security anxieties and perhaps undermine China's relations with Japan and the United States. On the other hand, the deployment of a significant BMD system in Japan to protect both U.S. forces and Japanese citizens could help to deter Pyongyang from attacking the South while lowering the likelihood that the North Korean ballistic missile threat to Japan would generate rifts between Tokyo and Washington during a Korean crisis or conflict. As in the case of Taiwan, U.S. decision-makers must carefully weigh both the military and political implications of ballistic missile defense for Japan.

India-China-Pakistan: The robust pace of ballistic missile acquisitions by India and Pakistan could increase the chances of war on the subcontinent between two proto-nuclear powers. Specifically, the possession of significant numbers of ballistic missiles—especially if armed and deployed in the field—could lead either or both powers to miscalculate in a crisis, perhaps opting for preemptive military action. In addition, the possession of ballistic missiles and WMD warheads might lead Pakistan to take greater risks in supporting insurgent activities in the disputed Kashmir region, again increasing the chances of miscalculation and direct conflict with India. Also, the acquisition by India of significant numbers of IRBMs could prompt China to increase its deployment of both MRBMs and IRBMs, thereby raising tensions beyond the subcontinent. All these possible developments could significantly affect the U.S. capability to play a stabilizing role in Asia. The likelihood of an Indo-Pakistani conflict involving ballistic missiles has arguably increased following the terrorist attacks in the United States on September 11 and in India since December 2001. Since these events, India has increased significantly its pressure on Pakistan to cease its alleged support for terrorist acts against India and the Indian portion of Kashmir. Both countries have engaged in a massive military buildup and (at the time of publication) war of words. The calculations of both countries in the resulting tense environment could be significantly influenced by their possession of growing ballistic missile inventories capable of delivering WMD warheads. The implications of this are clearly a major consideration behind the series of recent visits to the subcontinent by senior U.S. and other diplomats attempting to defuse the military standoff.

Possession of ballistic missiles and WMD warheads might lead Pakistan to take greater risks in supporting insurgent activities in the disputed Kashmir region.

Proliferation

Missile transfers (both exports and imports) by several Asian countries—most notably Russia, North Korea, China, and possibly Pakistan and India—could greatly influence U.S. efforts to limit WMD and ballistic missile acquisitions within and beyond Asia. In particular, such transfers could: 1) assist the efforts of non-missile states to acquire ballistic missiles and perhaps even WMD warheads; 2) strengthen the capabilities of existing ballistic missile states in Asia and beyond; and 3) increase the likelihood that terrorists or other non-state actors hostile to U.S. interests might obtain ballistic missile capabilities. Some observers believe that continued transfers of ballistic missile technology to states of concern to the U.S. will definitely result in the development of a network of technology traders and increase the sources of proliferation.[136]

As indicated above, China, North Korea, and Russia could pose a growing threat to the United States as exporters of ballistic missile technologies to countries hostile to the United States or to sensitive regions critical to U.S. security interests. For example, Russian assistance has greatly accelerated Iran's ballistic missile program.[137] Moreover, significant levels of political or economic instability are currently evident in North Korea and Russia and could conceivably emerge in China over the next 10–15 years. Such instability could result in the loss of central control over ballistic missile-related items and thus increase the likelihood of unauthorized transfers of missile-related technologies and materials.

Three proliferation-related concerns surround India and Pakistan. First, the highly competitive nature of the ballistic missile and WMD build-up between the two countries might make relevant technologies available to other nations, because in their haste to develop their own capabilities each side might devote less attention to ensuring such technologies are not acquired by other states. Second, both countries look to their suppliers for further technical assistance, strengthening these relations whether or not they are isolated internationally. Third, a breakdown of political order in Pakistan or the emergence of a radical Islamist regime there could result in significant transfers to both state and non-state actors.[138] The latter possibility has arguably become far more likely since the events of September 11. Those events led Pakistani President Pervez Musharraf to undertake courageous efforts to suppress Islamic radicalism throughout state and society, thereby threatening enormous internal unrest in the form of an Islamist backlash.

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[136] *Rumsfeld Report*.
[137] *Ibid*.
[138] *Ibid*.

Direct Threats to the United States

Ballistic missile developments in Asia also pose a more direct threat to the United States, primarily in two ways: 1) by threatening U.S. territories, including the U.S. homeland; and 2) by threatening U.S. forces deployed in the region. However, significant controversy exists over many aspects of these ballistic missile threats, including the scope of threat posed, the urgency of the potential threat, and the significance of at least one of these threats for U.S. security strategy.

The Asian countries that might pose a credible and realistic ballistic missile threat to U.S. forces in Asia and to U.S. territory over the next 10–15 years are North Korea, China, and perhaps India. Of these three countries, North Korea is arguably of greatest concern. Although the threat posed to U.S. forces in Asia by North Korea's existing missiles is clear, immediate, and unmistakable, the threat posed to the continental United States is less so. Indeed, the actual ability and willingness of North Korea to develop ballistic missiles capable of striking various parts of the United States with conventional and especially WMD warheads are hotly debated. Some observers argue that North Korea (and possibly other powers) could develop ICBMs capable of reaching large portions of the United States quickly and without much, if any, advance warning.[139] Other observers counter that such estimates are greatly exaggerated (given the many technical obstacles facing the development of ICBMs) and argue that even if North Korea were to develop a credible long-range missile, fear of a massive retaliatory strike would prevent it from launching such a missile against the continental United States.[140] Although this may be true, some argue that a North Korean ability to strike U.S. territory could deter Washington from exercising certain military-political options (e.g., the destruction of the Kim Jong Il regime) in the event of a war on the Korean Peninsula. Thus, at the very least, the development by North Korea of even a few ICBMs could significantly

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[139] China's strategic nuclear missile arsenal does not constitute a credible deterrent against a conventional missile attack, since any threat to employ those few weapons would immediately escalate a limited, conventional attack to the far more dangerous nuclear realm, and thereby threaten national annihilation by the United States' vastly superior strategic arsenal. The *Rumsfeld Report* states that: "…a nation with a well-developed, Scud-based ballistic missile infrastructure would be able to achieve first flight of a long range missile, up to and including intercontinental ballistic missile (ICBM) range (greater than 5,500 km), within about five years of deciding to do so." The authors add: "The question is not simply whether we will have warning of an emerging capability, but whether the nature and magnitude of a particular threat will be perceived with sufficient clarity in time to take appropriate action."

[140] See Cirincione, "The Political and Strategic Imperatives of National Missile Defense."

complicate U.S. strategy and constrain U.S. freedom of action in a crisis involving Korea. In response to this possibility, some observers argue that the United States must deploy a highly effective NMD system capable of intercepting all North Korean ICBMs, whether launched in a first-strike or in retaliation to a U.S. first-strike. Opponents to this viewpoint counter that such a NMD system is both unfeasible and potentially destabilizing, since it could lead Pyongyang to undertake highly dangerous preemptive actions in a crisis in the belief that it would have nothing to lose in doing so.

China's ballistic missiles also pose a threat to both U.S. forces and territory. As indicated above, the latter threat has existed since the early 1980s but has in the past been countered by the retaliatory capabilities presented by the U.S. nuclear arsenal. Nonetheless, some observers believe that growing Chinese economic and military power, China's increased involvement in the Asia Pacific, and the arguably worsening Taiwan problem will combine to increase the threat posed by the modernization of China's long-range missiles and nuclear weapons over the next 10–15 years. In particular, some argue that the presence of a more modern Chinese ICBM force (perhaps including more effective submarine-launched ballistic missiles) could deter the United States from responding effectively to a regional crisis involving China, such as over Taiwan. Some observers conclude from this that any future NMD system must be capable of protecting the United States against not only a North Korean missile attack, but also against any attack involving China's larger and more sophisticated ballistic missile force. Without such a leak-proof "shield," they argue, the United States will be unable to defend Taiwan adequately in a crisis and thereby ensure U.S. credibility. Opponents counter that even more than in the case of North Korea, the very attempt to build and deploy such a NMD system against China could be highly destabilizing. It might produce an offensive-defensive arms race, prompt China to resolve the Taiwan issue by force before a U.S. NMD system can be deployed, or seriously escalate an otherwise containable crisis over Taiwan. It is extremely hard—if not impossible—to imagine that any U.S. president would prosecute an expanding conflict against China over Taiwan in the belief that the U.S. homeland had been made entirely safe from a possible Chinese ballistic missile attack. No currently conceivable BMD system could guarantee total protection against Chinese ballistic missiles, and the stakes involved in such a Taiwan-centered conflict would simply not be high enough for a president to risk the catastrophic damage that would result from even one Chinese missile striking a U.S. city.

At least one observer argues that the presence in Asia of significant numbers of ballistic missiles capable of striking U.S. forward-deployed forces will severely undermine the credibility of the U.S. security presence by greatly increasing the hazards and costs of remaining the dominant power in the region. This analyst maintains that the threat posed by Chinese and/or North Korean ballistic missiles—especially if armed with WMD warheads—will fundamentally weaken, if not destroy, the entire strategy of forward engagement and put major strains on U.S. relations with friends and allies in Asia.[141] This argument probably overestimates the military and resulting strategic consequences for the United States of SRBM, MRBM, and IRBM deployments in Asia over the next 10–15 years. Nonetheless, at the very least it underscores the need for the United States to carefully examine the many implications for U.S. security interests of ballistic missile developments, including ballistic missile defense.

Appendix: Types and Components of Ballistic Missiles[142]

Types of Ballistic Missiles

Short Range Ballistic Missiles (SRBMs): SRBMs are the most common type of ballistic missile found in military arsenals because they are the easiest to manufacture and the most commonly proliferated. SRBMs generally are single-stage rockets and often utilize liquid-fuel propulsion systems. Due to their short range, some SRBMs do not leave the earth's atmosphere during flight. Some (known as "depressed trajectory") are even designed to fly at low trajectories to avoid detection and minimize time available for countermeasures.

SRBMs are generally seen as tactical, counter-force weapons intended to degrade an adversary's military capabilities or to deter an adversary on the battlefield. As a consequence SRBMs usually deliver conventional, high explosive warheads. However, some SRBMs are capable of delivering small WMD warheads and thus can serve strategic functions as both counter-force and counter-value weapons.

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[141] Paul Bracken states: "To preserve the situation in which the greatest military power in Asia is the United States, not any Asian country, arms-control agreements must prevent ballistic missiles from rendering impotent America's system of bases, the key to our forward-engagement strategy." Paul Bracken, "America's Maginot Line," *Atlantic Monthly*, December 1998.

[142] The information in this *Appendix* is drawn from the websites of the Federation of American Scientists <www.fas.org>, the Carnegie Endowment for International Peace <www.ceip.org>, and the Center for Defense and International Security Studies website <www.cdiss.org>.

Medium Range and Intermediate Range Ballistic Missiles (MRBMs and IRBMs): MRBMs and IRBMs are few in number compared to the high rate of SRBM proliferation. One reason for this is the 1987 Intermediate Range Nuclear Forces Treaty, which eliminated all U.S. and Soviet nuclear ballistic missiles with ranges between 500 km and 5,500 km (excluding air or sea-launched missiles). The treaty also forbade either party to sell such missiles to a third party. As a result, only a few other countries in Asia have managed to build their own IRBMs at this time: China, and perhaps India and North Korea. China, North Korea, India, and Pakistan all possess MRBMs.

More sophisticated than SRBMs, with more advanced engines and often multiple stages, MRBMs and IRBMs have traditionally served as counter-force or counter-value strategic weapons against potential adversaries. To compensate for loss of accuracy at greater distances, the preferred armaments are nuclear, chemical, or biological warheads. However, in recent years improvements in guidance and propulsion systems and conventional explosives have resulted in the development of MRBMs with conventional warheads, ostensibly for tactical counter-force purposes.

Intercontinental Ballistic Missiles (ICBMs): ICBMs are long-range missiles heretofore possessed exclusively by nuclear powers as delivery systems for nuclear warheads (although they can also deliver chemical and biological warheads). Hence, they are seen exclusively as both counter-force and counter-value strategic weapons. Within Asia, other than the United States and Russia, only China possesses ICBMs, although India and North Korea both reportedly have ICBM programs. The technological sophistication needed to produce ICBMs is very high and involves the development of three-stage serial boosters. The majority of ICBMs are solid-fueled, though some older ICBMs had liquid propellants.

Submarine-Launched Ballistic Missiles (SLBMs): SLBMs are long-range missiles (usually between MRBM and ICBM range). Their mission is primarily the same as that of ICBMs—to conduct a nuclear assault against another nuclear power's homeland. SLBMs are extremely rare. In the Asia Pacific only China, Russia, and the United States possess strategic submarines and their payload, and no other country in the region has an SLBM development program.

Phases of a Ballistic Missile's Flight

A ballistic missile's flight consists of three phases: the initial boost phase, the ballistic (midcourse) phase, and the terminal phase.

Boost Phase: The boost phase is the first part of a missile's flight, when it is powered out of its launcher with thruster engines and (relatively) slowly climbs to the upper limits of the atmosphere or beyond. The climb starts at about 4 Gs and reaches about 30 Gs at final burnout. The boost phase generally lasts about 80 seconds for solid-fueled ICBMs, or as long as 5 minutes for less advanced, liquid-fueled ICBMs.

Midcourse (Ballistic) Phase: The midcourse phase generally takes place in the upper atmosphere or through space. The first-stage thrusters used to power the missile out of the boost phase are spent and allowed to detach and fall away. During this phase ballistic missiles are generally propelled by momentum and cannot be controlled. The length of the midcourse phase depends on the distance traveled; ICBMs approaching their maximum range will take around 25 minutes to complete this phase. At the end of the midcourse phase the missile reenters the atmosphere. At this point, second-stage thrusters may activate, allowing for more controlled steerage and acceleration to correct course deviations caused during the boost phase. Missiles with finned steering systems can be fired at more shallow arcs in order to spend more time in the atmosphere, allowing for a greater amount of time to maneuver onto the target. During the midcourse phase, the missile may also release decoys or countermeasures to foil missile defense systems.

Terminal Phase: The terminal phase is the final stage of the arc, when the missile is falling back toward the earth. The terminal phase generally lasts 1 or 2 minutes but involves a great deal of heat and stress on the warhead, as the missile at this point is traveling at very high velocities; heat shielding is required to protect the payload from burning up. Reentering the atmosphere may throw the missile off target by as much as 20 km, so guidance systems from the post-boost vehicle (PBV) may be used to improve accuracy.

Components of a Ballistic Missile

A ballistic missile can be broken down into three main components: the control systems, the propulsion system, and the reentry vehicles. A fourth component—countermeasure systems against missile defense systems—may become increasingly common on future ballistic missiles.

Control Systems: Control systems, also referred to as post-boost vehicles (PBVs), provide steering and flight stability to counteract unequal weight distribution. Missiles with PBVs can achieve a CEP (circular error probability—the radius from the target within which half the launched missiles can be expected to fall) of within 500 meters at ICBM ranges, although the technological sophistication required to field control systems capable of effectively guiding long-range missiles has created a ceiling for many countries, effectively limiting their arsenals to SRBMs. Most of a missile's deviation from its intended trajectory occurs during the boost phase, and a smooth propulsion system is needed to achieve high accuracy. The type of warhead may obviate the need for such accuracy—a nuclear warhead with a yield of 20 kilotons may have a CEP as large as 3 km and still accomplish its mission.

The control systems can be divided into the autopilot (responsible for in-flight steering during the ballistic phase) and the terminal guidance system (responsible for end-flight targeting and homing). The steering system may be located anywhere along the missile and is usually electrical in operation.

The autopilot steers and stabilizes the missile with the use of thrusters and stabilizer fins during flight and has two main functions: 1) it keeps the missile from tumbling out of control, and 2) it keeps the missile steady along its flight path. Because of a missile's high speed and long range, deviation from course of even a few millimeters can cause the missile to miss the target entirely. Through the use of accelerometers, the control system maintains a steady flight attitude by constantly monitoring the missile's acceleration in range, altitude, and azimuth. Any errors in these trajectories will cause the autopilot to adjust the missile's flight. The autopilot may also receive signals from a guidance (targeting) computer, causing it to shift direction in order to better intercept its target.

Over long distances some form of navigational tracking is required. The oldest and least desirable is command guidance. Command-guided missiles receive radio signals from triangulated points on the globe to track relative position. Their disadvantage is that these signals are dampened by the boost of the rocket and may be easily jammed. The simplest and most reliable method is inertial guidance, which directs the rocket during its boost phase onto an arced trajectory that will place it mathematically on target. Although the launch site has no flight control over the missile with this method, the guidance system's accelerometers prevent outside forces (such as wind, gravity, and/or inter-atmospheric friction) from pushing the missile off target. A third navigation system is celestial guidance, which uses fixed stars to constantly reference the missile's position. The benefit to this system is that accuracy is not diminished by range, making it the standard system for ICBMs and SLBMs. The disadvantage of this method is that it requires the missile to carry a great deal of complicated equipment and to fly above the clouds in order to reference the stars.

Guidance systems activate at the end of the missile's flight to home the missile onto the target and ensure an optimal detonation. Not all missiles have a guidance system, and those that do not depend on their trajectory to hit their target once the rockets have exhausted their fuel and disengaged. Guidance systems can be active (such as radio frequency homing devices) or passive (such as optical tracking, infrared, etc.). The most sophisticated guidance computers utilize GPS (global positioning satellite) technology to assist targeting.

The Propulsion System: The propulsion system is the rocket (or rockets) designed to carry the warhead through the boost portion of its trajectory. The rockets must accelerate to supersonic speeds quickly so that the missile becomes effective even at short ranges.

A mixture of two chemicals—a fuel and an oxidizer—powers propulsion systems. There are two main forms of these chemicals: liquid and solid. Liquid propellant systems store the chemicals in different chambers, mixing and burning them during the boost phase. This method is very efficient and allows for some measure of control by regulating the chamber valves. However, liquid propellant systems require a great deal of fueling time prior to launch and a high degree of maintenance. For ICBMs, liquid fuel cannot be transported in the missile tanks. Thus a liquid-fueled ICBM requires hours of fueling time during its launch preparation, significantly diminishing its credibility as a deterrent to a nuclear strike.

Solid propellants are pre-mixed compounds of fuel and oxidizer. Although they are more stable and require less plumbing than liquid-fuel systems, they are much more difficult to manufacture and cannot be controlled once ignited. Solid propellants are desirable not only because they are stable, but also because they are far faster to prepare than liquid propellants (in contrast to liquid fuel, solid propellants can be readied and launched within minutes).

A third type of fuel system is a hybrid system, consisting of a solid fuel separated from a liquid oxidizer. This method is relatively stable, generates the most energy, permits relatively fast preparation, and allows for control of thrust by regulating the flow of oxidizer.

The range of a missile can be extended by attaching additional rocket boosters in parallel or serial configurations. Parallel rockets consist of clusters of rockets that burn simultaneously to increase the boost, but the tanks do not fall away when they are spent, and the force is not efficiently allocated throughout the missile's flight. Serial rockets are far more efficient and complex, operating in multiple stages and allowing for greater range. Once the first rocket booster segment expends its fuel, it detaches and falls away to lessen dead weight, revealing a second rocket booster segment behind it ready to ignite. Serial rockets afford greater control over powered flight maneuvering by timing each stage's ignition. However, timing between the detachment of the spent rocket to the ignition of the next is a difficult but critical design problem, as control of the missile will lag in the interim. The smoother the transition between stages, the more accurate the missile.

The Warhead/Reentry Vehicle: ICBMs that cruise in space during the ballistic phase utilize a special warhead vehicle to penetrate the atmosphere during descent. Prior to the terminal phase, a reentry vehicle (RV) will detach and set course onto the target. The thermal-shielded RV is shaped like a bullet (ballistic) or with fins (lifting). Ballistic RVs have a stable but steep and rough crossing into the atmosphere—but have no guidance control. RVs with a lifting configuration take a shallower reentry course, steering along the way, allowing them to attack targets not in line with the missile's trajectory and lessening turbulence and heat assault during reentry. The disadvantage to lifting designs is their expenses and lack of stability should the guidance system fail.

The warhead itself has a detonating device consisting of a proximity fuse (triggered electronically by the guidance system) and a contact fuse (which triggers automatically on impact). Safety mechanisms prevent the warhead from arming until the missile is safely away from the launch site.

The explosive itself may either be conventional high explosive, chemical, biological, or nuclear. High explosives, which are easy to manufacture and reliable, are the most common type of warheads. Their limited blast radius, however, requires them to be extremely accurate to successfully carry out their missions. Reliable terminal guidance systems are thus extremely important for longer-range missiles with conventional warheads.

Launch Platforms

The number of ways that ballistic missiles can be launched is limited due to their size, although there are several types of launchers.

The simplest method is a stationary launch platform or silo. These are the least preferred because they are easily monitored by an enemy and can be targeted by preemptive strikes. To overcome this drawback, the launch platforms often are hidden in valleys or in hardened, underground bunkers. Some missiles are placed in caves and rolled out to the launcher at the cave's entrance. Transporting a missile to its launcher lengthens launch preparation time, a critical consideration for missile forces designed to deter an enemy attack with the threat of a swift counterattack. Furthermore, there is no guarantee that the cave mouth or launch site would survive a first attack.

A second form of launcher is a road- or land-mobile system such as a trailer, truck, or railcar. Once it reaches its launch destination, the trailer can raise and fire the missile. Road mobility greatly increases the effective range of theater ballistic missiles and allows them some degree of evasiveness in the case of a preemptive attack. The missiles deployed on a mobile launcher will generally be solid-fueled; liquid propellant needs to be carried in separate tanks and then transferred to the missile before launch, increasing preparation time. Railcars offer swift and smooth railroad mobility, but have the disadvantage that the missile launch site is limited to the railroad, and mobility could be foiled or delayed by a strike on the tracks. A better option is the TEL (transporter erector launcher), a large truck that launches the missile from its back, allowing some off-road mobility, thus extending the evasiveness and range of the missile. TELs generally cannot carry as large a missile as a trailer or railcar.

The most effective launch platform for a ballistic missile is the strategic submarine, which is capable of launching numerous warheads from underwater. Submarines provide a high degree of stealth and the ability to approach enemy shores before launching an attack, reducing the time available to take missile defense measures. They also are likely to escape a missile attack on their homeland.

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