STATEMENT OF

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Some Thoughts on ICBM Development and ICBM Threats

Introduction

Chairman Tierney, Ranking Member Shays, distinguished members of the subcommittee, thank you for the opportunity to appear before you today. As requested, this statement provides some brief observations on the development of ICBMs and ICBM threats. I wish to acknowledge the collaboration of colleagues at CRS, especially Mary Beth Nikitin and Paul Kerr, in preparing this statement.

Overview

There are any number of different kinds of threats to U.S. national security interests. Some of these include threats from ballistic missiles, which have a range from a hundred or so kilometers up to about 10,000 kilometers. This statement focuses on the issue of longer range ballistic missiles, or ICBMs (Intercontinental Ballistic Missile) armed with nuclear warheads.

ICBMs are long-range ballistic missiles,[1] with ranges exceeding 5,500 km (about 3,500 miles), that carry one or more nuclear warheads. Historically, most have been deployed in land-based silos. Long-range ballistic missiles also have been deployed on mobile land platforms and at sea on submarines, in which case they are referred to as SLBMs (Submarine Launched Ballistic Missile). ICBMs and SLBMs are sometimes referred to as strategic missiles. In the past 50 years, there have been many hundreds, and perhaps more than a thousand long-range ballistic missile flight tests between the five ICBM powers. There have also been some 2,000 nuclear tests.

I last appeared before this subcommittee in 1992 during its investigation of the Patriot missile defense system's performance during Operation Desert Storm. It is useful to recall that during the 1991 war with Iraq, what we thought we saw, and what we were told, was not necessarily, as it turns out, what actually happened.[2] This underscores the importance of rigorously examining assertions concerning weapon system development and performance.

The Paths Taken

Results. Since the dawn of the rocket age, only five countries (the United States, Soviet Union/Russia, the People's Republic of China, Britain and France) have demonstrated the ability to develop, test, and field ICBMs armed with nuclear warheads. Since the early 1960s, there have been any number of intelligence assessments and studies that predicted there would be more than five nations that could have accomplished this capability at various times in the past 40 to 50 years.

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[1]A ballistic missile is guided through a relatively brief powered phase of flight after launch then it continues through space in free flight toward a predetermined target after reentering the Earth's atmosphere.

[2]*Performance of the Patriot Missile in the Gulf War,* Hearing before the Legislation and National Security Subcommittee of the Committee on Government Operations, April 7, 1992.

Why is this so? Why has this number not increased as many had predicted? I believe that no small part of the reason lies with the serious technical challenges that countries face in building an operational ICBM armed with a nuclear warhead.

This statement briefly discusses some of the technical and organizational and management challenges that nations face in developing nuclear armed ICBMs. The five countries that today have such capabilities all needed to overcome these challenges, and in some cases by receiving significant help from another country. A review of these challenges can add perspective to assessments of the likelihood that other countries might develop, deploy and threaten U.S. national security interests, and perhaps lead to a better estimation of those likelihoods.

Technical Challenges in Developing ICBMs. There many key parts of an ICBM, not counting a significant number of smaller components that all have to perform together successfully. This section briefly reviews some of the major parts, including the propulsion system, guidance system, payload or compact nuclear device, and reentry vehicle. Additionally, the issue of testing, especially that of the entire ICBM system, is discussed. Moreover, proper organization and management of ICBM development programs are also critical for their success.

Propulsion Systems.[3] Both solid- and liquid-fueled ballistic missiles present a variety of challenges for ICBM developers.

Liquid-Fueled ICBMs. A number of developing countries can manufacture fuel and at least crude components for short-range, liquid-fueled ballistic missiles. However, because of the greater stresses inherent in ICBMs during launch and powered flight, the challenges in designing and manufacturing components and engines for ICBMs is more difficult.

The Office of Technology Assessment (OTA) observed that, in order to control and terminate thrust precisely and avoid gross inaccuracies, liquid-fueled engines capable of delivering sufficient thrust to deliver a 500 kg payload more than 1,000 to 1,500 km must employ a much more complex system of valves, pressurizers, flow-control meters, and actuators than are needed for less powerful engines.

If ICBM developers choose to use inferior components, it might be necessary to include a post-boost vehicle that can provide course corrections during flight. Incorporating such a vehicle, however, "would present an entirely new set of design problems," according to OTA.

Solid-Fueled ICBMs. Solid fuel propulsion systems provide several advantages over liquid-fueled systems. For example, they can be readied for launch more quickly than liquid-fueled equivalents. However, such propulsion systems "require years of practical experience to design and develop successfully," according to OTA.

In solid-fueled missiles, the propellant is first mixed, then cast into the missile case, where it hardens. According to OTA, the casting process is the "most challenging aspect of manufacturing solid-propellant motors." For example, the propellant must be cast into the missile case in such a manner that the fuel bonds properly to the missile wall and avoids "cracks or voids," either of which

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[3]This section is based on U.S. Congress Office of Technology Assessment, "Technologies Underlying Weapons of Mass Destruction," OTA-BP-ISC-115, December 1993.

could "expose additional surface areas within the propellant, causing it to burn erratically or reach the wall prematurely, resulting in catastrophic failure of the motor."

Additionally, the design of the propellant itself is important to ensure that it will both burn at a proper rate and withstand the stresses of flight. And as the propellant burns, the center of gravity for the missile changes throughout its powered flight, creating additional design, development, test and operational challenges.

Solid-fueled missiles can also present unique challenges for testing. For example, a missile that explodes on a test stand may leave little or no recoverable data useful for assessing the test failure, especially for countries with little to no experience from which to draw. It is one thing for a country such as the United States to experience a launch-pad failure and have the capability to draw on decades of experience and data, and another thing for a country to face a similar failure without having a historical development record of its own.

Guidance System. One of the main parts of an ICBM is a guidance system that directs the missile and its payload toward its target. There are several possible guidance methods available, but some have proven unacceptable because they could be readily thwarted.[4] Instead, modern ICBMs use inertial guidance systems because they are completely self-contained, do not rely on external sensing, and have become quite accurate over time. They are immune to jamming and cannot be prevented from functioning short of tampering with the missile itself.[5]

Inertial guidance systems measure missile acceleration to determine position and velocity, calculate the velocity required to reach its target, and direct the rocket thrust to match that velocity.[6] As the missile accelerates in three dimensions, components such as accelerometers and gyroscopes allow the guidance system to measure the forces being applied to the missile from the time it lies in its silo to when the unpowered missile is accelerating under the force of gravity. As part of this system, on-board guidance computers use detailed mathematical models to help ensure the missile goes where it is intended.

Because ICBMs are somewhat unique in function, being unlike other military systems and to some degree different from shorter-range ballistic missiles, inertial guidance systems become a key challenge for a country developing ICBMs for the first time. ICBMs accrue navigational errors throughout their launch, flight and reentry.[7] Testing of such missiles and their reentry vehicles produces data in which mathematical models can be developed, tested, and fine-tuned against additional flight tests in an interactive manner. Such a process is technically challenging and time consuming. A pattern of ICBM flight testing is arguably necessary and cannot be hidden from the world.

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[4]A missile could be guided by electronic commands from ground stations, apparently with considerable accuracy. The problem, however, is that such missiles and ground stations become vulnerable to electronic jamming.

[5]"Ballistic Missile Guidance and Technical Uncertainties of Countersilo Attacks," Matthew Bunn and Kosta Tsipis, Report No. 9, Program in Science and Technology for International Security, Massachusetts Institute of Technology, August 1983, pp. 8-12

[6]Ibid.

[7]Ibid.

Compact Payload. Developing a reliable nuclear warhead that can fit on an ICBM is a challenging task. Moreover, such an endeavor would be difficult to conceal because conducting an explosive test of a nuclear device is widely regarded as critical for developing such a warhead.

A 2002 report from the National Academy of Sciences (NAS) states that, without nuclear explosive testing, states can only develop and certify "simple, bulky, relatively inefficient unboosted fission weapons."[8] A 1996 Department of Defense report described a "simple fission weapon" as one that "could be delivered by aircraft or tactical missiles."[9]

According to the NAS report, an aspiring nuclear-weapons state might be able to build an implosion-type weapon weighing between about 450-900 kilograms. That country could have only limited confidence that such a device would work. Moreover, public reports suggest that even this type of device would be difficult, if not impossible, for countries such as North Korea and Iran to deliver via ICBM.

A 1999 Defense Intelligence Agency (DIA) report, for example, states that North Korea will not be able to develop a nuclear warhead lighter than 650-750 kilograms in the "near term." Pyongyang's Taepo Dong-2, even if operational, could only "deliver a 650-kilogram warhead to Alaska, Hawaii, and the Pacific Northwest, or a much lighter warhead to most of the United States," the report says.[10] The NAS study asserts that, without nuclear testing, Iran could produce only "heavy and inefficient first-generation fission weapons."

For the ICBM powers, the reliability requirements imposed on the nuclear warhead itself are reportedly more stringent than on the delivery system.[11] These requirements are quantified in the damage expectancy and the mathematical likelihood that a planned attack will destroy its intended target. The damage expectancy depends not only on the warhead's explosive yield, but on the overall weapon system performance: a successful ICBM launch, separation of the booster stages, performance of the guidance system, disengagement of the RV from the missile itself, and the accuracy of the RV as it approaches its target.

Whether countries could effectively deliver chemical or biological weapons via ICBMs is unclear. According to a 1993 Office of Technology Assessment report,

> Without very sophisticated technology, ballistic missiles are not well suited for delivering chemical or biological weapons to broad-area targets. Such targets are most effectively covered with an aerosol spray delivered at slow speeds and low altitudes upwind from the target, a delivery profile much better suited to cruise missiles or aircraft.

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[8]National Academy of Sciences, *Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty*, 2002.

[9]*Proliferation: Threat and Response*, 1996.

[10]Excerpts from the report can be found in Rowan Scarborough, Rumsfeld's War: The Untold Story of America's Anti-Terrorist Commander, Regnerey Publishing, 2004

[11]"If it Ain't Broke: The Already Reliable U.S. Nuclear Arsenal," Robert W. Nelson, *Arms Control Today*, April 2006.

The report also described delivering a chemical or biological weapon via a separating warhead as a "theoretical possibility." It should be pointed out that no country is known to have deployed such warheads on ICBMs, in part because of what are considered enormous technical challenges.

Relatedly, a 2001 National Intelligence Estimate (NIE) argued that countries could well choose other means to deliver chemical and biological weapons:

> Some of the states armed with missiles have exhibited a willingness to use chemical weapons with other delivery means ... In fact, US territory is more likely to be attacked with these materials from nonmissile delivery means—most likely from terrorists—than by missiles, primarily because nonmissile delivery means are less costly, easier to acquire, and more reliable and accurate. They also can be used without attribution.

Nevertheless, the OTA report stated that "by the 1960s the United States had developed submunitions for ballistic missiles that would spread chemical and biological agents more efficiently than would release at a single impact point." And Richard Garwin argued that "ballistic missiles intended to cause damage to the United States are not likely to have nuclear warheads" because it is easier to develop "individual bomblets" deliverable via ballistic missile, that would disperse biological agents.12

Reentry Vehicle. In the last stage of flight, the reentry vehicle (RV) enters the atmosphere with a velocity of several kilometers per second. Aerodynamic and other forces create the most severe environment in the life of an ICBM, heating the RV to temperatures of thousands of degrees centigrade, and tens of gravities of deceleration. For most of its reentry, an RV is surrounded by a field of ionized plasma and looks like a burning meteor streaking across the sky.[13] According to Bunn and Tsipis

> The design of vehicles that could survive such environments was one of the foremost challenges in the early days of ballistic missile development. To protect the warhead from the extreme heat of reentry, blunt high-drag RVs were designed, which would slow down quite rapidly as soon as they encountered the upper atmosphere, reducing the thermal load experienced later; large and heavy heat shields absorbed what heat did build up, protecting the warhead inside.

The disadvantages to this became apparent as the heavy weight reduced potential warhead yields and the high drag shapes of the RVs and relatively slower reentry meant the RV was more susceptible to winds and varying atmospheric densities, which in turn reduced accuracy. This approach gave way to what became a highly specialized reshaping of the RV tip to a more conal shape using materials covering the outside of the RV that burned off uniformly and predictably.

This new approach, and increasingly over time, the design of the external RV material allowed for extremely high reentry speeds under a variety of reentry conditions, thus permitting significant

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[12]Richard L. Garwin, "What We Did," *Bulletin of the Atomic Scientists*, November/December 1998, Vol. 54, No. 6; Garwin argued that states would be unlikely to place chemical warheads on such missiles because a "hundred- or thousand-fold greater mass of chemical agent [would be] required to equal the damage done by a bioweapon attack on an unprotected population."

[13]"Ballistic Missile Guidance," Bunn and Tsipis, p. 39.

accuracy improvements. However, reshaping the RV meant that the nuclear warhead component had to be redesigned and tested. Moreover, these specialized materials, characterized as militarily critical technology, required new manufacturing processes and infrastructure.[14]

[14]Frank T. Tracesk, "Assessing Industrial Capabilities for Carbon Fiber Production," *Acquisition Review Quarterly*, Spring 1999.

Full System Testing. From the time a missile lies dormant in its launcher to its launch, powered and unpowered flight, atmospheric reentry and then fusing or detonation, navigational and other errors begin to develop and accumulate. Testing of all the component parts can help reduce as much as possible such structural or inherent errors even in proven systems, but according to experts they cannot be eliminated entirely.[15] It is generally accepted that operational tests of the system are necessary to know whether and how well the entire system will work, and the degree that further testing may be required to ensure the ICBM will launch successfully and operate as planned.

Some systems that have been considered fully vetted in developmental and operational tests have experienced problems, even after their deployment. For example, some of the deployed early U.S. long-range submarine ballistic missiles were later shown to have unacceptable failure rates.[16] Even more recently, some of the long-range ballistic missiles used as test intercept targets for testing the U.S. ballistic missile defense (BMD) program have failed to launch or operate to allow those BMD tests to proceed. This, despite 50 years of considerable U.S. long-range ballistic missile flight test experience.

Additionally, it is worth noting that to date there has never been an end-to-end full system test of an operational ICBM where a deployed strategic missile was launched from its silo or from a submarine to a target at ICBM range to include a successful nuclear warhead detonation. The closest examples occurred in 1962 when a U.S. submarine test launched a medium-range ballistic missile and its warhead impacted and detonated near Christmas Island in the Pacific,[17] and in 1966 when the Chinese test launched a short-range DF-2 to its nuclear test site at Lop Nuar and air-bursted a nuclear warhead.[18]

Management and Organization. In addition to having access to the appropriate materials and technology, states wishing to deploy ICBMs must also have a strong development program.[19] Aaron Karp argues that

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[15]Ibid., pp. 128-138.

[16]For instance, a safety feature on the Polaris A1 warhead worked well in development and testing, but often jammed in operational situations such that three out of four of these warheads were considered potential duds. Bunn and Tsipis, "Ballistic Missile Guidance," p. 128

[17]U.S. Nuclear Tests: July 1945-1992, Department of Energy, DOE/NV-209 (Rev. 14), December 1994, p. 13. This test is known as Operation Frigate Bird.

[18]John Wilson Lewis and Xue Litai, China Builds the Bomb, Stanford University Press, 1988, pp. 202-203.

[19]This section is based on Aaron Karp, Ballistic Missile Proliferation: The Politics and Technics. SIPRI/Oxford University Press 1996. pp. 51-98.

There is much more to any major R&D project than just assembling metal and plastic. Easily overlooked are the necessary skills, experience and judgment required of engineers and programme managers. Also behind every missile programme are conceptual, organizational, financial, and command and control factors, each imposing its own problems for ballistic missile development.

Particularly for a program as ambitious as developing an ICBM, it is critical to devise the proper design strategy, as well as provide competent program management, the appropriate number of personnel, and sufficient financial resources.

As a point of illustration, the early U.S. ICBM development effort involved an estimated 80,000 people and extensive industrial participation.[20] Gen. Bernard Schriever, who led the effort to produce an operational U.S. ICBM, chose what he called a risky development path and a revolutionary change in management and administration of a military program. This included clear and vertical decision-making channels on overall program and policy matters, high national level priority for funding, and complete responsibility and authority for program direction at the operating management level.

Karp also states that, although countries may receive considerable amounts of foreign assistance in their missile programs, "would-be rocket makers are almost entirely on their own" in the area of program management. "Foreign companies and governments can offer advice and their own example, but little else," he adds.

For example, both appropriate organizational and managerial choices have proven critical to missile programs when governments are choosing their development strategies. Karp argues that an "incremental development" strategy, in which a missile program moves "in sequence through progressively larger designs, improving the performance of major components, and gradually introducing new ones," is the most effective. Citing France's program as the best example of this strategy, Karp notes that development of new French missiles "never required more than 14 test-firings and never took longer than six years to reach deployment."

By contrast, states that have begun their missile programs by taking "huge leaps" tend to face greater difficulties. For example, the United Kingdom began by developing an IRBM (Intermediate Range Ballistic Missile); the program eventually collapsed. Similarly, India began its program with work on space launchers in the early 1970s. According to Karp, New Delhi "endured false starts and serious delays."

Karp acknowledges that incremental development strategies are "not a panacea" and that the United States and Israel successfully leapt "over stages in rocketry development." However, he also says that "small powers" and countries with "weak technological-industrial capabilities" face "grave risks" if they take any approach other than the incremental one. Countries with "scarcer resources" are less able to recover from mistakes.

Space Launch Vehicles (SLVs). Some countries could develop a civilian space launch capability as a cover for foreign acquisition of technologies relevant to ballistic missiles.

[20]It has been estimated that 18,000 scientists, 17 prime contractors, 200 subcontractors, and 3,500 suppliers, employing about 70,000 people were involved in the early U.S. ICBM development effort in the mid-late 1950s. "The Man Who Built the Missiles," Walter J. Boyne, *Air Force Magazine*, October 2000, p. 85

Nevertheless, according to experts conversion of an SLV to an ICBM is technologically challenging and is not necessarily the intention of a civilian program.

An SLV capability would give a country experience in building large boosters and high-quality guidance systems relevant for an ICBM program. Nevertheless, unlike SLVs, ICBMs need to reenter the atmosphere toward a predetermined target. Simply put, SLVs must go up but ICBMs must also come down again and therefore require a reentry vehicle (presumably with a warhead) capable of surviving the forces and stresses of reentering the Earth's atmosphere at those velocities. Changes would need to be made to the engine, the airframe (to survive reentry), and guidance and control systems would need to be reprogrammed to fly a ballistic missile trajectory. Additionally, SLVs typically require long launch preparation time, which a country would normally want to avoid for its ballistic missiles to retain military relevance and survivability. It is also not crucial that an SLV be precise in its boost phase to place a satellite in orbit, whereas minor deviations are significant for surface targets, even with weapons of mass destruction as the payload.[21]

A country with a demonstrated SLV capability may be considered capable of developing ballistic missiles generally, but the obstacles to success dramatically rise when talking about converting an SLV to an ICBM. The quantity and sophistication of the technologies that need to be integrated increase significantly. A September 1999 NIE stated, "many SLVs would be cumbersome as converted military systems and could not be made readily survivable, a task that in many cases would be technologically and economically formidable."[22] A country could not mask an ICBM reentry vehicle test as a space launch test. Without testing the reentry vehicle, the country could not have confidence in delivering the weapon.

All five ICBM states also have active space programs. Outside of these five cases, two others – India and Japan – are particularly illustrative. India's space program is an example of a civilian program used as means for ballistic missile development. India first adapted its SLV-3 to create the medium-range ballistic missile "Agni." There is now discussion in the open-source literature of whether (and why) India might convert its Polar Space Launch Vehicle (PSLV) to a presumably nuclear-armed ICBM (the "Surya"). The "Surya" would reportedly be a three-stage missile with the first two stages derived from the PSLV and a third stage potentially derived from India's Geosynchronous Space Launch Vehicle (GSLV).[23] Japan, on the other hand, has had a SLV program for 30 years, with its most advanced system the H-IIA. Japan reportedly has consistently made engineering decisions that make these systems less useful militarily.[24] While many analysts seem to

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[21]U.S. Congress Office of Technology Assessment, "Technologies Underlying Weapons of Mass Destruction," OTA-BP-ISC-115, December 1993; Aaron Karp, Ballistic Missile Proliferation: The Politics and Technics, SIPRI, Oxford University Press, 1996.

[22]"Foreign Missile Developments and the Ballistic Missile Threat to the United States Through 2015," National Intelligence Council, September 1999.

[23]See Richard Speir, "India's ICBM– On a "Glide Path" to Trouble?", The Nonproliferation Policy Education Center, February 7, 2006.

[24]Japan has focused on SLV's that use the most energetic propellants available (cryrogenics – liquid hydrogen and liquid oxygen), which is a logical choice for SLV's as it maximizes the payload to orbit capabilities. Cryrogenic propellants, however, are ill suited for ICBMs, as they are not "storable." Having to fuel a missile prior to launch (an hours long process) is considered strategically unacceptable. SLVs, on the other hand, can be launched according to readiness, so fueling times are not relevant.

agree that Japan could develop an ICBM if it wanted to, the SLVs it has made are apparently not designed to be converted to military use.[25]

Alternative Paths to ICBM Development

There has been much discussion in the decade since the 1998 report by the Rumsfeld Commission that some countries such as Iran, Iraq and North Korea could develop ICBMs in a significantly different manner. There are several key assumptions made to support this line of thought.

First, countries will pursue alternative paths to building ballistic missiles that will not require "high standards of missile accuracy, reliability and safety, nor large numbers of missiles." Second, countries will obtain significant foreign assistance in developing ballistic missiles. Third, having or building short range ballistic missiles such as SCUDs provides the means to develop ICBMs.

As discussed above, there are basic components necessary for building an ICBM, regardless of development path. Integrating the numerous components of an ICBM is a true technical challenge. Additionally, a country will not be able to hide their testing of reentry vehicles. Deploying an ICBM without testing would, according to the 1999 National Intelligence Assessment (NIE), result in "significant reduced confidence in their reliability."

[25]Jeffrey W. Thompson and Benjamin L. Self, "Nuclear Energy, Space Launch Vehicles, and Advanced Technology," in Japan's Nuclear Option, The Henry L. Stimson Center, 2003.

Foreign assistance of course could speed up development of ICBMs and nuclear warheads, but some observers state most suppliers appear to be withholding meaningful assistance. Arguably, gaining foreign help with ICBMs has become more difficult over time.[26]

Additionally, the Rumsfeld report tends to assume that there is a straight line in development from short-range, single stage SCUDs to an ICBM. Arguably, there are significant differences in the requirements to develop a successful ICBM program with multiple stages that will transit through space and reenter the atmosphere under extremely different conditions.

Even without a "high standard" of accuracy and reliability, a country still needs to develop propulsion and guidance systems, compact payloads, and reentry vehicles that will simply work together successfully and not terminate in a catastrophic failure. From the experience of the ICBM powers, such efforts are not easily hidden or masked.

Current long-range ballistic missile threat assessments from the intelligence community appear to rely heavily on the key assumptions seen in the Rumsfeld Commission report from a decade ago. These assessments appear to be a key driver in the U.S. BMD effort. Some would argue that perhaps these assessments should be revisited.

Summary

Few countries have successfully developed and deployed operational, nuclear-armed ICBMs. The developmental record of their efforts indicate how challenging that effort was. The fact that more nations have not done this is perhaps witness in part to the extraordinary technical effort it took. The long history of ICBM development in the five ICBM states demonstrates that such success

[26]Joe Cirincione stated that China reportedly aided the missile programs of Iran, Iraq, Libya, North Korea, Pakistan, Saudi Arabia, and Syria, although the extent of that assistance has been greatly reduced in recent years. See, Joseph Cirincione, Testimony before the U.S.-China Economic and Security Review Commission, Hearing on China's Proliferation and the Impact of Trade Policy on Defense Industries in the United States and China, July 12, 2007. Additionally, some of the annual intelligence briefings to Congress included discussion of foreign ICBM development and foreign assistance. In this year's briefings there was no mention of such assistance. See, "Annual Threat Assessment of the Intelligence Community," J. Michael McConnell, Director of National Intelligence, Hearing before the Senate Committee on Armed Services, February 27, 2008, and "Current and Projected National Security Threats to the United States, Lt. Gen. Michael D. Maples, Director, Defense Intelligence Agency, Hearing before the Senate Committee on Armed Services, February 27. 2008.

took considerable resources in time, funding, knowledge, infrastructure, organization and national commitment. Even so, those efforts experienced significant failures along the way. And after 50 years of commitment and experience, some of these nations still experience occasional failures.

Moreover, alternative approaches will not necessarily be successful. It is difficult to see how a developing country could simply escape the demands of such resources and produce and deploy successfully a nuclear-armed ICBM without transparent failures or development along the way that can be observed.

Mr. Chairman, distinguished members of the subcommittee, this concludes my testimony. Thank you again for the opportunity to appear before you to discuss these issues. Mary Beth, Paul and I will be pleased to respond to any questions you might have.

Appendix
ICBMs: Who Has What?

Currently, the five nuclear-weapons states – China, France, Russia, the United Kingdom, and the United States, are also the countries which have ICBMS. Iran and North Korea are suspected of developing such missiles; those programs are most frequently cited as potential threats to the United States. Below are brief discussions of some of these countries.

China

China has approximately 20 ICBMs (liquid-fueled CSS-4s, range 12,900 + km). According to the 2007 Department of Defense "Annual Report to Congress on the Military Power of the People's Republic of China," Beijing's solid-fueled, road mobile DF-31 ICBM "achieved initial threat availability in 2006, and will likely achieve operational status in the near future, if it has not already done so." That missile has an estimated range of 7,250 km.

The United States projects that China will expand and continue to modernize its nuclear arsenal. The 2007 DOD report projected that by 2010 China's nuclear forces will "likely" include "enhanced" CSS-4s, DF-31s, and the DF-31A. The latter is a longer-range (11,270 km) variant of the DF-31, and was "expected to reach initial operational capability" in 2007, the report said. The National Air and Space Intelligence Center (NASIC) reported in 2006 that Beijing could increase its number of "ICBM warheads capable of reaching the United States ... to well over 100."

China is also expected to deploy a new SLBM, the JL-2, on a new JIN-class (Type 094) nuclear-powered ballistic missile submarine, which is in development. According to the Office of Naval Intelligence, the first of these submarines could reach initial operating capability "as early as 2008." The JL-2, which has an estimated range of over 8,000 km, is expected to reach initial operational capability between 2007 and 2010.

France

France has four ballistic missile submarines, each of which can carry 16 4,000 km-range M45 SLBMs. Each missile can hold up to six warheads. Although these missiles are not of ICBM range, Paris is developing the 6,000 km-range M51 SLBM to replace the M45. Paris has also been developing a new class of ballistic submarines; the last of the four is to come into service in 2010.

As of July 2007, Russian strategic nuclear forces included 104 10-warhead SS-18 ICBMs (range 5,500-6,000 km), 136 6-warhead SS-19 ICBMs (range 5,500 km), 222 single-warhead SS-25 road-mobile missiles (range 7,000 km), single-warhead, silo-based SS-27 ICBMs (range 7,000 km), and 3 single-warhead, mobile SS-27 ICBMs (range 7,000 km). Moscow also has 14 ballistic missile submarines, equipped with a total of 288 SLBMs (ranges 3,500-5,500 km).

Russia

Although Russia's strategic nuclear forces are expected to decline, Moscow might be able to deploy its new SS-27 ICBM with three warheads, instead of one. According to NASIC, Moscow may also be developing another missile, which "could be deployed in both land- and sea-based version," with an estimated range of over 5,500 km. The Strategic Offensive Reductions Treaty limits Russia and the United States to 1700-2200 strategic warheads, but each side can maintain a stockpile of nuclear weapons and the treaty expires the same day it enters into force-December 31, 2012.

The United Kingdom

The United Kingdom has fewer than 160 operationally available nuclear warheads. These are deployed on four Vanguard-class submarines, each of which carries up to 48 warheads on a maximum of 16 Trident D5 SLBMs. That missile has a range of about 7,400 km.

North Korea

North Korea has not successfully flight-tested an ICBM. Both a 1998 test of its 2,000-km range Taepo Dong-1 and a 2006 test of its Taepo Dong-2 failed. According to U.S. intelligence reports, the range of the Taepo Dong-2 is estimated to be 5,000-15,000 kilometers, depending upon whether it is deployed in a two or three stage configuration. The short flight time of the 2006 test, however, complicated a more exact determination of the launch vehicle's range and payload.[27]

Although former Defense Intelligence Agency (DIA) Director Lowell Jacoby told the Senate Armed Services Committee in April 2005 that North Korea had the capability to arm a missile with a nuclear device, Pentagon officials later backtracked from that assessment. A 2008 Director of National Intelligence report to Congress says that "North Korea has short and medium range missiles that could be fitted with nuclear weapons, but we do not know whether it has in fact done so."

Iran

Iran claims to have flight-tested a variant of its Shahab-3 ballistic missile with a range of 2,000 km. – the longest range Iran has claimed to date. Iranian officials have stated that Tehran's Ashura and Ghadr missiles also have a range of 2,000 km. Iran reportedly conducted an unsuccessful flight test of the Ashura missile this past November.[28]

U.S. intelligence officials told the Senate Armed Services Committee in February 2007 that the intelligence community believes that Iran could develop an ICBM by 2015.

[27] Paul Kerr, "Security Council Condemns NK Missile Tests," *Arms Control Today*, September 2006.

[28] Peter Crail, "Iran Lauds Development of Solid-Fuel Missile," *Arms Control Today,* January/February 2008.