FEASIBILITY OF THIRD WORLD ADVANCED BALLISTIC AND CRUISE MISSILE THREAT
Volume 1: Long Range Ballistic Missile Threat

The Systems Assessment Group of the NDIA Strike, Land Attack and Air Defense Committee began this study using aerospace industry analysis tools and judgments to address the feasibility of a Third World country to develop or acquire a long range ballistic missile. Volume 1 of the study reports the assessment of the feasibility of the long range ballistic missile threat. A subsequent Volume 2 report will cover the cruise missile threat. The analyses performed by industry under the broad title of "Feasibility of Third World Advanced Ballistic & Cruise Missile Threat" incorporate information only from unclassified sources.

This study examines the potential growth in ballistic missile range that could occur as a result of the unprecedented proliferation of ballistic missile technology to Third World countries. The study focuses on the question of *feasibility* rather than traditional intelligence methods which are based primarily upon observed data. The study also considers that Long Range Ballistic Missiles (LRBMs) might be developed by Third World countries for coercive purposes wherein a small number of weapons with reduced performance may be sufficient to achieve certain political objectives. Toward that end, unconventional design processes are considered as a means to significantly reduce the development time required to achieve such limited capability.

Our focus on LRBMs does not ignore the growing threat to US allies and theater assets posed by shorter range ballistic missiles. The study recognizes a number of Third World countries who also have a missile development infrastructure capable of developing new intermediate range ballistic missiles. The development of those other long range missiles provides valuable learning and may actually achieve some of the milestones critical to Third World country developing an ICBM-class missile.

Agenda

Industry has attempted to present in this report a complete yet succinct story of the Third World ballistic missile threat. The report begins by tracing the transfer of technology from the German's WW II V-2 rocket; describes the technical capabilities and ballistic missile inventory of Third World countries; estimates the time needed for them to develop and launch a longer range ballistic missile based on configuring available boosters in stack or cluster form; verifies the flight stability and performance characteristics of weight, propulsion, payload, and range; and lastly provides a set of observations.

The study supports the report recently released by the Rumsfeld Commission by providing an independent assessment of the near term technical feasibility of Third World LRBM development. We base our assessment upon historical examples and upon observed and publicly reported trends.

Industry analysts have applied engineering design experience, accepted performance models, and a realistic understanding of the essential building blocks of a missile program to describe LRBM design options for a motivated Third World country .

This assessment does not rely on unrealistic technical breakthroughs. Both political and technical obstacles to such a Third World weapon program are considered. The missile designs offered are feasible today for a number of Third World countries. Despite economic sanctions against likely LRBM developers, there is ample evidence of technology proliferation that supports the development of LRBMs.

Study Objectives

The study focuses on an assessment of technical feasibility and innovative design techniques for the development of long range missile capability. However, the time required to develop such capability may vary substantially according to intended use and the level of performance required. Certain fundamental performance requirements which must be met in order to achieve a minimum long range missile capability are (1) controlled flight to desired range and (2) warhead re-entry and fusing.

Accuracy and payload weight may be of secondary importance depending upon the intended use of the weapon. For example, weapons of coercion are designed to instill a degree of fear in the minds of a population, which may be accomplished by a single demonstration that a warhead can be flown to the target country's homeland. If biological or chemical payloads are used, the accuracy and size of the warhead is of little additional concern. These considerations of intended use can have a dramatic impact on shortening missile development timelines.

The study presents an assessment of LRBM development capability which is supported by evidence of technology proliferation, Third World proclamations of intent, and, not least of all, the publicized progress toward ever longer range missiles to attain political influence over the U.S.

Study Approach

In order to meet the objective of this study, which is primarily an assessment of technical feasibility, it was judged necessary to adopt new, innovative paradigms for the missile development process - paradigms that are in many cases the antitheses of traditional US and former Soviet Union weapon development processes. For instance, it is reasonable a LRBM acquired for political purposes may not need the reliability, survivability, responsiveness, and performance that a militarily rugged missile may require.

To stimulate such "out of the box" thought processes, the study began with a review of other Third World missile programs, including WWII Germany. Germany, though not Third World at that time, actually possessed far less technical knowledge than exists today in Third World countries, and yet was able to successfully test an ICBM design before the end of the war. How fast were Iraq and North Korea able to develop ballistic missiles? What types of missions were the weapons designed to accomplish?

In addition the study looks at open source material regarding current Third World missile development programs, and conducts an assessment of key technological challenges to achieving long range capability. Finally, several candidate configurations using innovative techniques are postulated and evaluated for range/payload performance using computer simulation.

Definitions

Ground launched ballistic missiles are typically categorized by their range capabilities. U.S. military services, U.S. intelligence agencies and U.S. civilian contractors all delineate ballistic missiles into four range classes -- SRBMs, MRBMs, IRBMs, and ICBMs. No official corresponding range classification is made for submarine launched ballistic missiles (SLBMs) or cruise missiles (CMs), because arms negotiators have understood that launch platform mobility can change the weapon's effective range (and hence its time of arrival at a target).

There are several treaties (mainly bilateral US-Russian) in effect which restrict the types and numbers of offensive and defensive missile systems that the U.S. or other major world powers can develop and deploy. Unfortunately, none of the Third World countries projected to be capable of developing LRBMs are bound by these treaties.

Agenda

A knowledge of the past development of ballistic missiles will help us understand more fully the serious threat they pose today. The history of ballistic missilery in Germany, North Korea, and Iraq will be traced. We will be reminded that Germany during World War II was the innovator of ballistic missilery by developing the V-2 rocket in 1942 and launching it upon England in 1944. Germany considered also using unconventional payloads of chemical or radiological agents. Further, it had on the drawing board booster designs to increase the V-2 range so it would be capable of reaching the U.S.

Like Germany in WWII, Third World countries today have made national commitments to ballistic missile development. The missile development history of North Korea and Iraq exemplify the technical progress attainable when countries remains undaunted by international sanctions or even defeat in war.

It appears that a *voluntary* agreement among 29 countries called the Missile Technology Control Regime (MTCR) has done little to thwart the migration of missile technology.

Historical Analysis Objectives

Understanding the impact of national motivation is a key factor in the assessment of a Third World country's ability to successfully develop an LRBM. National priority provides focus and resources. Design trade offs must be evaluated and completed quickly rather than debated. Performance requirements must be universally understood in the context of overall mission objectives, thereby enabling design compromises that are easy to resolve through a relaxation of requirements and modification of the operational concept as necessary to continue to satisfy top level mission objectives. Reliability may be sacrificed in order to reduce development time. Mission objectives could be satisfied by planning for an operational concept to fire two missiles instead of one in order to achieve the same overall probability of mission success for each target.

THIS PAGE INTENTIONALLY BLANK

Key Ingredients of the German Program

A convergence of political/cultural trends and forces which began in the Weimar republic of the 1920's and continued through the growth of Nazi Germany in the 1930's produced a highly favorable environment for the rapid development of the German ballistic missile program. Interest in rocketry and spaceflight was widespread throughout the general population of the Weimar republic of the 1920's. The 1924 Fritz Lang science fiction film "Frau in Mond" (The Woman in the Moon) was technically accurate and immensely popular. This followed the establishment of the Society for Spaceflight (VfR) in 1927, which included eventually the 19 year old Wernher von Braun.

German Army Ordnance (LtCol Becker) with less altruistic objectives established Section 1 with the objective of reestablishing the rocket as an artillery weapon (not controlled by the Versailles Treaty). The initial focus of Section 1 was the development of advanced solid rockets for the delivery of chemical warfare agents. As Section 1 grew Becker hired von Braun away from the VfR. Shortly after Hitler came to power in 1933 there was immediate suppression and dissolution of the German amateur rocket societies and the immediate security classification of all technical data. This resulted from the belief by LtCol Becker and others in Army Ordnance that advanced rocket development could be the basis for technological and operational surprise. This evolved to the first large black program of the twentieth century.

Although there was a series of advances and setbacks in the priority of the German ballistic missile program it ultimately received very high national priority and significantly large amounts of funding. The program proceeded at a rapid pace considering the fact that virtually all critical technologies had to be created from scratch. This was possible because of the excellent German domestic industrial base and its ability to do rapid prototyping using a series of technology demonstrators; A-3, A-5 leading to A-4(V-2).

German ICBM Design

WWII Germany had completed a design for a two stage ballistic missile with a 3000 mile range capable of reaching the east coast of the United States. The upper stage was a modified A-4 (V-2) utilizing a blended wing that allowed it to glide on re-entry thereby providing the required range extension.. This configuration was actually tested on two occasions prior to the end of the war. It should also be noted that Germany progressed from a SCUD class missile (V-2), to the early test phase of an ICBM in less than 4 years.

<u>Detailed Background</u>

As early as 1940 (two years prior to the first successful A-4 flight test), von Braun's development team began to explore potential solutions to the attainment of dramatically improved range and accuracy of future ballistic missile systems. Several approaches to range extension were investigated including higher specific impulse (Isp) propellant combinations, large high thrust scale-up of the A-4 rocket engine, boost glide, and staging. von Braun chose boost glide as the primary approach for range extension of single stage vehicles within the European Theater. The A-9 was a radical blended wing boost glide vehicle based on the A-4 which was intended to increase the missile's range to 595 km compared to the A-4's 320 km range. This would bring deep theater targets within range. The ultimate concept for range extension was the A-9/A-10 Amerika Rocket which was a two-stage ICBM with a design range in excess of 5000 km intended for attack on New York and deep targets within the Soviet Union.

The price of range extension was further worsening of system accuracy from the A-4's 19-km CEP. The Peenemunde team's approach to accuracy improvement was the development of a piloted A-9 concept which would have employed a pilot-in-the-loop terminal guidance system employing some form of radar sensor. After completing the terminal correction maneuver, the pilot would eject and would be recovered by a rescue submarine.

The pressure of A-4 development and production priorities led to the abandonment of these concepts; however two first flight tests of a more conservative swept wing A-4 derivative (the A-4b) were conducted in early 1945 shortly before VE day.

Design for Use of Chemical/Radiological Payloads

Germany recognized the value of employing warheads of mass destruction on the V-2 rocket. However, they also came to believe that a nuclear bomb was probably not feasible (they believed that an entire reactor would have to be dropped on the target and sent critical). They did recognize however, the potential utility of a radiological weapon of mass destruction which could be delivered to London using the V-2. The above design shows a modified V-2 containing a mid-section payload compartment designed to break and roll away from the rocket intact if the missile were to explode on launch. A large facility was apparently under construction at Watten for the production of radioactive isotope to be mixed with sand and packaged in the payload canister.

Recent investigations by the British military historian Philip Henshall have unearthed a previously classified engineering drawing of a hither to unknown A-4 variant which includes provision for chemical or radiological payloads. In this configuration the nose-mounted conventional high explosive warhead was deleted and replaced by ballast. The payload section was moved to a highly reinforced ribbed cylindrical module which apparently was designed to contain the chemical or radiological payloads in the event of an A-4 launch failure. German Army Ordnance had sponsored studies of the effect of nuclear radiation on biological systems. One concept was to produce tailored radioisotopes (possibly in a reactor in a large hardened launch facility such as Watten) and mix them with a sand dispersal mechanism. Although the German nuclear program failed to provide an atomic bomb, the crude nuclear reactors under development for this program could have been a source of radioisotopes.

Alternative Concept for Attacking North America

Even though this study is focused on long range ballistic missiles, it is worthwhile to observe that other means may also be employed to threaten a target country. The WWII German design postulated here was an alternative for attack against CONUS by employing a V-2 packaged in a watertight container which would be towed by submarine to within 100 miles of the coast; at which time the canister would surface, rotate to the vertical, and launch the V-2. Although this project never left the drawing board, it nevertheless provides an excellent illustration of an innovative thought process.

The Peenemunde rocket development team undertook a forward-development of this concept which was designated Projekt Lifevest. A special diving container was designed to carry a standard production V-2 missile which would be towed behind a type XXI class U-boat into firing position off the East coast of the United States. (New York was the favorite target). The tow cable provided both electrical power and firing commands to the container. The base of the Lifevest container contained a dewar flask for storage of liquid oxygen and a ballast chamber. The missile launch was accomplished by filling the ballast tank which erected the container so that its top surfaced. The missile was then fueled, the firing door opened, and the missile launched. Only one of the Lifevest containers was completed by VE day.

While the technical concept was feasible, its operational viability was questionable considering the declining prospects for U-boat survivability and the inherent reliability problems with the A-4 missile.

THIS PAGE INTENTIONALLY BLANK

North Korean Ballistic Missile Programs

For almost three decades, North Korea has exhibited the national will and concerted effort needed to accomplish significant missile advances in spite of international condemnation and non-proliferation sanctions. These advances have not been totally indigenous efforts; relying heavily on foreign technical and economic assistance.

North Korea's internal economic woes seem to have little effect on its achievement of a long range ballistic missile capability. An ICBM (10,000 km-class missile) is forecast as feasible for North Korea based on an extension of Taepo-Dong 2 assessed performance.
While the intelligence community currently estimates a North Korean ICBM capability by 2008, based on the performance of the August 1998 attempted space launch, a politically useable ICBM could be available in 1999.

Western intelligence indicators have been unreliable, and surprise has been the hallmark of each incremental improvement to North Korean family of increasingly capable ballistic missiles. The August 1998 launch was anticipated to be a two-stage missile, not a three-stage missile actually flown, though the North Koreans claimed it to be a space launch. Despite some successes at detecting sales of these weapons, critical components, or associated technologies to Middle Eastern "rogue states" and possibly others, the proliferation of advanced missile systems from North Korea has proceeded unabated.

The North Koreans have stated they will continue to export missiles including LRBMs. News reports in August 1998 identified representatives from Third World clients who were on hand to witness the LRBM launch.

THIS PAGE INTENTIONALLY BLANK

Iraqi Ballistic Missile Programs

As early as the 1970s, well before the Gulf War with Iran , Iraq had committed itself on the path of developing a ballistic missile capability. It pursued a multi-faceted indigenous development program aided by other countries. Development efforts covered every aspect of missile subsystems from warheads and fusing to guidance, control, propulsion and structures. Early governmental approval of farsighted plans enabled the construction of a highly capable manufacturing, test, and operations infrastructure. The willingness of foreign technical specialists in many critical technology fields to participate in the development was enabled by the enormous oil wealth committed to the projects.

That many of those scientists and engineers came from ostensibly U.S. allied countries testifies to the dual attractions of money and a technical challenge. Even after the bombing of Iraq during Desert Storm and the imposition of UN sanctions, sufficient resources and technical capability remained to build a new indigenous TBM, the Al Hamid.

In hindsight, the acquiescence then by the very countries which now decry the proliferation of missile technology laid the foundation for much of the missile threat the world now faces. The UN inspectors recently prevented from inspecting certain Iraqi facilities may have gotten too close to what continues to be a massive missile weapons manufacturing capability.

Genealogy of Technology Transfer After WWII

This genealogy depicts one clear fact: Critical missile technology cannot be contained despite the Missile Technology Control Regime. The MTCR, a partnership of 29 countries attempting to restrict the proliferation of ballistic missiles, has been spectacularly unsuccessful to date. The above chart illustrates how missile technology has migrated from WWII Germany to the former Soviet Union and the U.S., and then to the rest of the world. Engineers are willing to hire out to foreign governments if the price is high enough (e.g., a German team designed the Al Hussein for Iraq in the late 1980's). Many of the indigenous Third World missile programs evolved from a derivation of the Russian SCUD which has been sold and resold throughout Third World countries.

Virtually all post war ballistic missile system developments can trace their roots to the Peenemunde development activities which resulted in the A-4 (V-2) SRBM and its derivatives such as the Wasserfall Surface to Air missile system. The United States imported a number of V-2 missiles along with Werner von Braun and many key members of his development team under Project Paperclip. The Bumper WAC two-stage rocket, the Hermes test vehicle and the operational U.S. Army Redstone SRBM incorporated technologies from the V-2 (aerodynamics, structures, GN&C, and propulsion) and from the Wasserfall system.

The Soviet Union also acquired and launched a number of V-2's and Wasserfalls. The V-2 was put into production as the R-1 and deployed operationally. The Korolev OKB (design bureau) then developed the R-11 SRBM which was the first storable propellant Soviet ballistic missile which was a scale up of the storable propellant Wasserfall SAM. Production and further development of the R-11 and its derivatives was spun off to the Makeyev OKB in the 1950's which evolved the design into the R-11FM (the first Soviet SLBM) and the Soviet Army R-17 SCUD which was essentially an evolved storable propellant V-2. Ballistic missile technology spread quickly to the Peoples Republic of China and then to many other countries, leading to the emerging LRBM threat we face today.

International Technology Transfer

Most Third World countries with limited indigenous ballistic missile development or production capabilities will likely turn to foreign sources. They can be expected, initially, to approach those suppliers with whom they have existing weapon acquisition agreements.

Shown here is an overview of ballistic missile-related technology transfers from 1985 through 1992 to nine Third World countries of interest. It should be noted that these countries' preferred sources will change as their political goals and alliances develop along with financial resources that can be directed to developing and deploying weapons of mass destruction (WMD).

Most of the Iraqi ballistic missile technology transfers occurred before the Persian Gulf war. However, those pre-war Iraqi investments successfully established a missile development and WMD infrastructure which remains largely intact today in spite of international inspections.

Missile Technology Control Regime (MTCR)

The Missile Technology Control Regime (MTCR) is a partnership of countries attempting to restrict the proliferation of ballistic missiles, cruise missiles, unmanned air vehicles, their components, and related technology. MTCR restrictions apply to exporting weapon systems capable of delivering a 500-kg payload to ranges of 300 km or greater as well as systems intended for the delivery of weapons of mass destruction (WMD).

The MTCR is neither a treaty nor an international agreement, but is a *voluntary* agreement among countries which share a common interest in arresting missile proliferation. The MTCR currently has 29 member countries with a number of non-MTCR signatories who abide by its guidelines.

The current members of the MTCR are Argentina, Australia, Austria, Belgium, Brazil, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Russia, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States of America.

Today, however, any Third World government with the political resolve and financial resources will have little trouble obtaining a ballistic missile force through a combination of purchases and indigenous development. Ballistic missiles and NBC weapons have ceased to be the exotic products of rare technology and are becoming commonplace.

What MTCR Doesn't Control

The weakness of MTCR lies in what it does not control. Contrary to its title, the MTCR does not control anything. It is not a treaty and contains no meaningful enforcement means. The signers of MTCR agree only to exercise restraint, subject to national interests.

Worse, some of the most damaging loopholes are not even subject to restraint. For example:

- **States that have not signed the MTCR are becoming suppliers of increasingly capable missiles.**
- **Technology and components used for non-military, commercial purposes (e.g., space launch vehicles, communications equipment, GPS navigation equipment) are equally applicable to ballistic missile weapon systems.**
- **An equally serious loophole is that MTCR places no restriction on emigration of experienced scientists and engineers to developing countries. Following the collapse of the Soviet Union and Russia's economy, thousands of these skilled people are unemployed.**
- **Foreign students are sent by their nations to study engineering and technical disciplines at the best schools in the U.S. and Western Europe. Physics courses teach trajectory analysis, guidance and control, and reentry dynamics and Chemical Engineering courses teach propulsion-related skills. Finally, Systems Engineering courses teach them how to put it all together. These well-educated students return home forming a significant part their country's weapons development infrastruture.**

For these reasons, any Third World government with the political resolve and financial resources will have little trouble obtaining a ballistic missile force through a combination of purchases, foreign assistance, and indigenous development. Ballistic missiles and NBC weapons have ceased to be the exotic products of rare technology and are becoming commonplace.

Agenda

Ballistic missiles held by Third World countries are identified by name and performance characteristics. The dominant trend is to develop longer range missiles. LRBM coverage in the order of 10,000-km range indicates that the northern region of the U.S. is vulnerable.

Third World Countries with Ballistic Missiles

Ballistic missile capabilities have been attained by these countries by several means: 1) direct purchase from a major world power or other Third World country; 2) developed internally with significant support from other industrialized countries; 3) indigenously developed with technology or components acquired from open or covert sources; or 4) completely indigenous development and production with minimal external support.

Two countries of concern (Iran and North Korea) are assessed to have the capability to develop ballistic missiles of 3,000 km range or longer. The regional influence of such weapons is shown on the map.

Third World Weapons Options Favor Missiles

The widely publicized lack of a deployed U.S. ballistic missile defense actually encourages the development of ballistic missiles as the weapon of influence for future adversaries. Indeed, the ability of the U.S. and other western nations to defeat aircraft, ground weapons and naval vessels makes those weapon options less valuable and motivates development of missiles which are more likely to reach their targets.
Unlike the huge training, operations and maintenance costs associated with acquiring or developing air, ground, or naval manned weapons systems, ballistic and cruise missiles can be operated for considerably lower cost. The high payoff of ballistic missiles drives Third World countries to select them as the most challenging threat against hi-tech western countries.

Source: US Army ADA School, Air and Missile Defense Master Plan (threat section),

Third World Indigenous Capabilities

Indigenous technical and industrial infrastructure of Third World countries determines their ability to acquire, modify, design, develop and test ballistic missiles independently. These capabilities vary drastically from country to country. Israel and India have the skilled people and technical infrastructure necessary to implement a broad range of ballistic missile developments. In the decade since the 1992 SDIO study shown here, Egypt, Iran, Iraq, and Pakistan were forecast to have only modest capabilities (without significant foreign assistance). Other Third World countries such as Libya, Saudi Arabia, and Syria are forecast to have only rudimentary capabilities and will be required to rely on outside sources to acquire or develop any weapons of mass destruction.

Israel currently has a robust industrial infrastructure and a highly developed ballistic missile program (Jericho series). India is capable of developing and deploying long range ballistic missiles (Agni), if threatened by external powers. Iran is actively developing a number of short and medium range weapon systems (Shahab-3/Zelzal-3) and has longer range and intercontinental range ballistic missiles (Shahab-4, -5, and -6) in the early stages of development. Iran is currently supported technically by Russia, China and North Korea.

Iraq is currently restricted by the Gulf War peace accord to developing ballistic missiles with ranges no greater than 150 km. Despite constraints imposed by sanctions and the presence of UN inspectors, Iraq recently flight tested a new SRBM proving it is still capable of advancing its missile capability.

Current Third World Ballistic Missile Capabilities

Until recently, the vast majority of Third World ballistic missiles were strictly battlefield or short range weapons only accurate enough for area targeting . A significant number of countries have or are now developing LRBMs capable of attacking targets well beyond their borders with large enough lethal payloads to obviate accumulated inaccuracies in guidance. (A typical target may be the capital of an enemy country or any U.S. base in the region.) Longer range ballistic missiles are being developed to deploy weapons of mass destruction (chemical, biological or nuclear payloads) as well as conventional high explosive warheads. Most of these ballistic missile systems are currently in the medium range (1,000-3,000 km) performance category. However, there is evidence from several sources that some countries are developing ballistic missiles with ranges in excess of 10,000 km. With these new, high technology and high performance weapon systems, a Third World country could attack almost any country in the world.

China is the leading Third World developer and producer of long range ballistic missiles. However, India, Iran, Israel and North Korea have active ballistic missile programs and are assessed to be able to develop, produce, and deploy limited numbers of long range ballistic missiles within the next 10 to 15 years.

Current Third World Ballistic Missile Capabilities

...continued.

Selected Countries with Ballistic Missile Development Programs

Iran and North Korea are currently the most worrisome countries able to build a long range ballistic missile in the near term.

According to BMDO, as referenced by *Inside The Army*, February 16, 1998, Iran's development program, aided by major external technical assistance, has established a significant ballistic missile development and fabrication infrastructure. However, there is no consensus within the intelligence community on timing for fielding of an Iranian MRBM capability -- the estimates range from mid-1999 to 2003. Because BMDO believes this threat is compelling, the uncertain timing forces BMDO to focus on the worst case scenario -- a capability in mid-1999. The uncertainty results from different understandings of what "fielded capability" means. BMDO, therefore, believes it is more likely that some time will pass after testing before Iran fields a limited MRBM capability.

Major regional capitals and key U.S. assets throughout the Middle East would be threatened by an Iranian MRBM. Successes in the Iranian new ballistic missile development and deployment will stress the development of both the Army THAAD and the Navy Theater Wide ballistic missile defense systems which are designed to handle the projected ballistic missile threat. Lower Tier systems like Patriot, Navy Wide, and Israeli ARROW TMD system will have only a limited defended area capability against MRBMs like the new 1,300 - 1,700-km Iranian Shahab-3/Zelzal-3.

North Korea's economic plight seems to have only slowed the development of relatively high quality tactical ballistic missiles. The infrastructure exists to develop systems beyond the Taepo-Dong-1 2,000-km range missile and they have demonstrated the national will to do so.

Potential Iranian LRBM Coverage

Iran's ballistic missile developments provide numerous examples of unexpected technical achievement and innovation by a dedicated country. Its missile development history reflects a steady progression toward a long range capability that exceeds its regional defense needs. The family of Shahab missiles now in flight test can be reasonably forecast to provide Iran with ICBM range weapons.

Given the priority Iran's missile programs have commanded, the covert development of WMD payloads is also likely. Concealed warhead development facilities may be located inside Iran or another country or hidden in the open like the "pharmaceutical laboratory" the U.S. attacked in Sudan after the terrorist bombing of U.S. embassies in Africa. The variety of concealment options and the resources being committed to Iran's missile program lead the study group to believe that waiting for positive identification of the threat to develop defenses against it may be too late. A future U.S. ballistic missile defense should expect to face an Iranian LRBM armed with a chemical, biological or nuclear payload of indigenous Iranian design whose development and testing may not have been attributed to Iran.

Iran’s Ballistic Missile Development Program Schedule

Immediately after the Iran-Iraq war, the Iranian indigenous ballistic missile production and design programs began in earnest. Close relations with the People’s Republic of China and Democratic Republic of Korea allowed Iran to acquire hardware and technology of the Chinese M-5, M-11 and possibly DF-3A, as well as the North Korean Scud-B Mod A/B, Scud-B Mod C and “Nodong-1” series of ballistic missiles. Sources in the former USSR may also have provided technology from the SS-4 and SS-20 MRBM/IRBMs as well as complete examples of the SS-12 SRBM. Advisors and experts on ballistic missile technologies from China, North Korea, Syria, former East Germany, Yugoslavia, Pakistan and the former Soviet Union have assisted Iran since 1986. As many as 9,000 foreigners are believed working within Iranian ballistic missile programs today. Iran has also contracted with foreign universities and institutes for expertise. In addition, Iran maintains its own personnel and funding presence in several foreign ballistic missile programs.

Iranian ballistic missile programs are managed and coordinated by Department 140 of the Iranian Defense Industries Organization. Major ballistic missile research and design is carried out by Shahid Hemat and Shahid Bagheri Industrial Groups near Tehran. Other ballistic missile technology, production and test complexes are located in Karaj, Semnan, Esfahan, Sirjan, Tabriz, Shiraz, Parchin, Khorramabad, Rafsanjan, Tabas and Sharoud. In many cases research centers for weapons of mass destruction are co-located with ballistic missile programs. Iran budgeted $300 million for ballistic missile research in 1997 and has spent roughly $1.2 billion since indigenous programs began in 1993.

License production agreements provided Iran with the ability to manufacture the basic Scud-B by 1990, Scud-B Mod C by 1997 and probably Nodong-1 by 1999. By 1997 Iran could export as many as 50 Iranian built Scud-B to Syria.

Among Iran’s indigenous ballistic missile designs is the mysterious “Tondar-68” -- reportedly a two stage ballistic missile or technology demonstrator -- was tested in 1991 and 1997. The single stage Zelzal-3 and two-stage Shahab-3 medium range ballistic missiles incorporate both liquid and solid fuel propulsion technologies from the Scud-B, DF-3A and M-11 series missiles. Six or seven static engine tests have been accomplished and fifteen complete ballistic missiles are being built for flight test. A follow on program in its early stages is the Shahab-4, a 2,000 to 2,500-kilometer MRBM. A 3,500 to 5,500-kilometer range IRBM is also under investigation. Finally, Iran is known to have plans for an ICBM to be flown before 2007.

Potential North Korean LRBM Coverage

The quest of the Democratic People's Republic of Korea (DPRK) to achieve an indigenous ballistic missile production capability dates from the early 1970s. It is believed that the North Koreans obtained a small number of SCUD-B ballistic missiles from Egypt in 1981, which they immediately began to reverse engineer. An extended range variant of the SCUD was probably the goal of their program from the beginning. Serious work began in late 1988-early 1989 which resulted in the successful test of the SCUD Mod C in 1990. It was a completely new design based on an extension of the Russian SCUD technologies and development experiences.

Two new ballistic missile, called the No Dong-1 and Taepo Dong-1, with estimated ranges of 1,300 km and 2,000 km respectively have been developed and flight tested by North Korea, while a naive world believed the country was ready to collapse. To date, there have been four or five known No Dong flight tests and a recent test believed to be the Taepo Dong-1. During 1990-91, the DPRK is believed to have initiated the development of another more sophisticated and capable ballistic missile -- the Taepo Dong 2, which has yet to fly. Various sources indicate that this new DPRK ballistic missiles will have a range of approximately 3500 km.

The four DPRC ballistic missile systems (SCUD Mod C, No Dong-1, Taepo Dong-1 and Taepo Dong-2), if ever fully developed and deployed, will give the North Korean military the capability to attack targets in the Asian region and possibly beyond.

Agenda

The availability of ballistic missile technology, subsystems and component equipment, test facilities, and external technical assistance permits a Third World country to accelerate the time it can develop, field, and launch a ballistic missile. Feasible shortcuts may not reflect "traditional" missile development paths.

Challenges to Third World LRBM Development

Despite daunting challenges, Third World countries that desire LRBM capability as a national priority can implement innovative <u>shortcuts</u> to bypass traditional western developmental experience and substitute adequate technologies in areas such as:

- **Safe propellant handling and accurate loading (liquid boosters): <u>commercial valves and flow controls</u>**
- **Consistent solid propellant processing (solids): <u>polymer chemistry and plastics manufacturing techniques</u>**
- **Adequate structural design and fabrication to integrate propellant tanks, engines and aero structure: <u>PC-based CAD software, Russian aerodynamic models</u>**
- **Design and application of thermal protection to heat sensitive booster components and payloads to survive LRBM high velocity reentry heating loads: <u>PC-based thermal analysis programs used by well-educated engineers /scientists</u>**
    - **Skill to design structural and thermal materials to protect boosters and interstages against high aerodynamic loads**
    - **Reentry system structural design skills, payload dynamic balancing, thermal protection, and shock isolation**
- **Guidance algorithms applied to ruggedized computers for pre-flight initialization and inflight system management; and flight sensors and power systems with autonomous thermal control: <u>commercial components and extrapolation from academic studies</u>**
- **Test range instrumentation to enable "fly-fix-fly" analysis to speed the development cycle: <u>Commercially available communications and recorders</u>**

Key Technical Challenges

Assuming a decision has been made to jump-start a Third World LRBM development from existing TBM technology and components, the remaining design challenges are significant but understood. While there are potential problem areas such as staging and vehicle control, there are also well-understood solutions to each of these challenges:

- Finding effective "shortcut" methods for clustering or stacking existing propulsion systems to create LRBM booster stages; matching the clustered rocket motors total impulse and burn time within a close tolerance (< 0.5%). Use of SCUD or CSS-2 class rocket motors (RD-214 and RD-216) as building blocks requires development or purchase of the technology that will enable propulsion matching. Booster design software also is complex, but attainable. Integrated software development may be achieved by using Matrix X rapid prototyping software and Excel tools with simulation-in-the-loop methodology such as CASE tools available globally. These tools are best sellers because they reduce software development costs by thirty percent and complexity by fifty percent.
- Ground handling and loading of large amounts of hazardous liquid propellants, even for "simple" SCUD-type fuels, is risky business. Similarly, attaining consistency in the performance of solid propellant grains requires technology that takes time and experience to master the art and science of propellant casting. Scaling up either liquid or solid motor technology to LRBM range capability can be challenging for design and manufacture. Because it is key to an indigenous LRBM program, propulsion developments by a Third World country would probably receive significant effort to conceal successes and failures. Concealment should be expected since propulsion systems can be integrated by foreign technical experts who would demand protection from international scrutiny.
- Controlling the missile's planned flight profile with variable burntime motors on each booster stage, monitoring the uncontrolled flexure of the missile structure, timing stage separation and next stage ignition, and updating an inertial platform not intended to fly to LRBM ranges are additional challenges. Flight programming software is available to construct trajectories using launch location and target position inputs. A trajectory simulation with 3 degree-of-freedom accuracy is adequate and is commercially available. The Orion PC-based launch vehicle performance program costs $4,000 and produces a tape or disk for loading into a missile's computer. This program provides pitch, yaw, and roll commands plus staging for the missile. Trial and error testing may be partially replaced with foreign expert knowledge of these pitfalls, but significant development effort may be required to integrate the components into a system never before flown.

Key Technical Challenges (Cont.)

•At ICBM ranges, a LRBM payload will experience high aerodynamic heating loads during reentry which require external and/or internal protection materials. There are abundant examples of innovative use of easily applied insulation such as cork and wood on missile payloads. Insulation must be considered since the nosetip of even a low ballistic coefficient payload is especially vulnerable to heating. Burnthrough during reentry at ICBM ranges would likely initiate a catastrophic failure of the warhead. Payloads also experience high dynamic loads which the primary structure must be designed to accommodate. The reentry payload must be shaped to provide some dynamic stability during reentry. This requires knowledge of high speed aerodynamic reentry environments, which requires accurately calculating and maintaining static margin.

• Ballistic missile targeting errors are a function of propulsive, aerodynamic, and guidance variants. LRBM guidance and control can be implemented off-the-shelf computer components and the navigation algorithms may be developed from published information. IRBM-class guidance and navigation is readily available using commercially-available aircraft guidance and navigation systems to provide adequate accuracy for a political weapon. Even old IRBM guidance accuracy of 3 nautical miles over ICBM ranges may be sufficient for a political weapon.

• To save time on such a high-priority national LRBM project, a major effort would be made to capture performance data from every test (including hardware-in-the-loop simulations). Collecting and understanding performance data would require operating instrumentation facilities compatible with the flight systems being monitored. The transmit and receive capabilities needed are widely available on the international market. Depending on concealment efforts, intelligence observers may not detect the progress of missile integration testing until the first (and possibly only) flight test.

The complexity of a LRBM development requires a major national effort as evidenced by programs in North Korea, Iran, pre-war Iraq, Pakistan, and India.

Critical Technologies

Although a number of Third World countries are capable today of indigenously producing tactical and short range ballistic missiles, the LRBM flight regime demands more advanced technologies. Development of LRBMs (up to ICBM ranges) will introduce problems requiring new booster and payload designs for operating environments more physically demanding than for SRBMs. The Third World countries must have the technical expertise to recognize and analyze these design challenges before they begin. They will likely acquire or adapt existing technologies to produce LRBM subsystems. Improvements are required in propulsion, structures and guidance elements as well as field deployment and flight operations skills.

For example, the SCUD ballistic missile family is limited to a range of 1000 km or less by the payload external structure. Third World ballistic missile developers will be required to employ external thermal protection materials not required for existing SRBMs. Without improvements, greater flight ranges will result in aerodynamic heating loads which will cause a burnthrough during flight.
Some system testing must be completed and at least one full scale flight must be successful to claim any capability for a new ballistic missile weapon system. The time between development and deployment will be driven in part by the desired degree of confidence in the system's reliability. The test and analysis technologies needed to "qualify" the ballistic missile are nearly as daunting as the fabrication challenges. Each ballistic missile developing country will determine the criteria for its own LRBMs considering financial and technical resources and mission.

Required Engineering Development Infrastructure

Many Third World countries have acquired weapons of mass destruction from other countries with developed military technologies. Most of these lesser developed countries do not have national resources to integrate the required material, technologies, facilities and skilled personnel to develop, produce, and deploy a ballistic missile weapon system. To bridge that technical gap, a number of foreign powers (Russia, China, and North Korea, for example) have proven eager to actively assist these countries develop weapon systems.

Alternately, a Third World country can attain many required technologies and ballistic missile subsystems directly or covertly from businesses all over the world, under the guise of commercial systems applications. The country must also have the political resolve to proceed in the face of inevitable discovery (by the time of initial flight test, if not sooner) and the financial resources to pay for the technical assistance while developing its own technical infrastructure. Given a high degree of skill, luck and an unwavering national commitment, a Third World country could complete a ballistic missile development program and begin deployment of a system that could have a degree of reliability sufficient to provide political influence or support some military objectives.

The required LRBM infrastructure may also be developed gradually during the development and testing of shorter range missiles. The lessons learned by integrating increasingly complex missile systems bear directly on a successful LRBM development. North Korea appears to have made several covert steps toward a space launch or LRBM capability with very little overt flight testing, They successfully incorporated Russian and Chinese systems engineering expertise and subsystems design into indigenous missile systems of improved configuration and may have advance computer simulation capability to verify performance to their own standards.

Third World Development Time Compression

Iran and North Korea have demonstrated it is possible to significantly compress the typical "western" missile development time schedule. For a political weapon to threaten opponents' homelands thus enabling a geopolitical advantage, a Third World nation may be willing to develop a minimally reliable, non-military capability that will meet its requirement to deter U.S. or allied intervention in a region. Compared to the rapid pace of development of some western systems, like the Minuteman ICBM, a Third World country with strong national will and resources may acquire foreign assistance and make even faster progress. The traditional missile development path is no longer applicable. A Third World LRBM development timeline may be modified by trading quality, reliability, and performance for shorter development time. Practices include reduced flight testing, acceptability of technology 20-40 years old, off-the-shelf integration, and a multi-national relationship between countries involved in cooperative efforts.

Iran's steady development of a substantial ballistic missile capability shows how a determined national effort can compress the "traditional" western missile development timeline.

Development Time Estimate

These development timelines depict the relative spans required for five feasible LRBM development approaches that a Third World country might pursue. The time spans required for acquiring LRBM capability range from buying a whole system to building an entire system intentionally for a military force.

The time between "earliest possible launch" (intensive foreign assistance, success-oriented shortcuts, overt testing) and the "most likely first launch" (less foreign assistance, covert integration, mature infrastructure) reflects an uncertainty about how successfully a specific country can combine foreign assistance and its indigenous capability. For example, the earliest possible launch of a LRBM built from existing missiles by clustering or stacking may occur in as little as 18 months with the most likely launch occurring 30 months after program start.

These timelines reflect a shortest possible time for each option to develop a few LRBMs with political utility intended to deter U.S. or allied actions and to gain a geopolitical advantage. Developing a more capable and reliable LRBM force in the numbers required to constitute a militarily useful force will require a substantially longer time. Building an entire missile is the only option for a dedicated military missile force.

Effective Time to Respond

This chart recognizes that the U.S. will likely not know precisely which development path a specific country has chosen. Although it is not yet possible to attribute LRBM design requirements to a specific Third World country nor know how and when technical breakthroughs are achieved, this chart implies that we may have relatively little warning time to respond when the existence of a LRBM program is finally proven. The first indicator may be the <u>first launch</u> (⬇).

Should the U.S. become aware of a country using the cluster/stack option to develop a LRBM, it may have only six months to defend against it after witnessing a launch.

However, there may be no test launches associated with the first two development options; purchase of an ICBM or conversion of a SLV. The first option reflects a concern based on unproven press reports of the potential purchase or theft of an ICBM. Continued organizational breakdown of the Russian military increases the probability of sale of one or more mobile SS-25 missiles or launchers without the knowledge of the Russian Government. Given the Chinese sale of CSS-2 missiles to Saudi Arabia, plausible scenarios could be developed for Chinese ICBM sales to selected countries to achieve geopolitical advantage.

The other development options also presume at least one flight test prior to IOC ("most likely first launch"). It is, however, possible that a separate country may be supporting tests of the whole missile system or parts of it thereby complicating attribution of a missile in flight test to its ultimate owner.

Agenda

Possible LRBM booster configurations are hypothesized. Their performance characteristics are determined by using advanced missile design models. Other options for LRBM development are described.

Options for LRBM Development
(Buy a LRBM)

One option is to buy a LRBM force as Saudi Arabia did, by purchasing 60+ CSS-2 missiles and support from China. Iran and Pakistan reportedly have helped fund North Korean development of No Dong and Taepo Dong missiles. In turn they have received help in developing their own missile manufacturing facilities and have received North Korean missiles and development support. There is also the fear that Russia or China, may sell an ICBM despite international political pressure. With disintegration of the Russian military this becomes increasingly likely, and China might export an ICBM to achieve geopolitical objectives. Considering the North Korean proliferation policy and their recent three-stage missile test flight, the possibility of a LRBM on the world market in 1999 becomes real.

Available IRBMs

An inventory of IRBMs exists among countries which have already demonstrated the willingness to export high technology to other countries. Countries able to export their missile systems can reduce or eliminate the development time required for a Third World country to attain a LRBM capability.

Options for LRBM Development
(SLV Conversion)

Three space launch vehicle (SLV) conversions are described: the Indian ASLV, Israeli SHAVIT, and the Japanese M-3 or M-5.

Many space launch systems were in fact derived from ballistic missiles. Four countries derived 19 different SLV's from 14 different ballistic missiles. Alternately, a country may develop a LRBM based on an indigenous SLV program. Possible countries are Argentina, Brazil, Indonesia, Israel, Japan, South Africa, Taiwan, Pakistan.

**Nine countries currently have SLV's and eight more are in some phase of planning or actually developing SLV's. Little or no distinction can be drawn between a civilian space program and a military program in the development phase, nor does the MTCR attempt to constrain commercial space development.
The policy of western developed nations has been to encourage the peaceful use of rocket technology and rocket technology is readily available to those countries developing space launch capabilities. This option would most likely be selected if only a few weapons were desired for use in political coercion, and the perceived need were near-term.**

A Third World country may perceive that converting a space launcher would draw less wrath from the nonproliferation community than an outright ballistic missile development. The recent North Korea declaration of a Taepo Dong as a SLV indicates they may try to sell a LRBM under in the guise of a SLV.

CIA Assessment of SLV-LRBM Conversion

A recently publicized report by the CIA identifies strong similarities between the technologies used for a SLV and those required for a LRBM. CIA's recent re-assessment of the WMD proliferation risk of such space launch vehicles was cited by Aviation Week in its June 1, 1998 issue.

The U.S. Government requested an American aerospace company to assess the effort to convert a proven SLV into an ICBM and to propose such a program. The resulting proposal defined a 30-manmonth effort. Knowledgeable engineers estimate most SLV conversions could be performed in a foreign country within six to 18 months depending on the SLV being modified, indigenous capabilities, and level of foreign assistance.

There are few differences between a launch vehicle capable of placing a satellite payload accurately in orbit and one that delivers a destructive payload to ICBM ranges. In fact, the capability of a missile to place a warhead into orbit was tested more than 20 years ago as the Fractional Orbit Bombardment System. The implied risk with such a capability in the hands of a Third World belligerent lies in not knowing when the ostensibly peaceful "satellite" payload may be deorbited over a U.S. city.

Indian ASLV Conversion

The Indian ASLV launcher configuration has been assessed for its ability to deliver a militarily useful payload to a distant target. The Jane's performance analysis shows what a developing nation with a coherent national will might achieve using indigenous talent to modify western technologies provided to it over a decade ago.

Israeli SHAVIT Conversion

The difficulties in producing a reliable solid booster have been largely overcome by the Israeli Jericho 2 ballistic missile system which is the closest relative to the Shavit space launch vehicle.
The use of a solid propulsion system enables this potential LRBM to be ready to fire from a secure storage location on short notice. The inherent difficulties of liquid booster fueling and storage are obviated by a solid system. The easier operation of solid boosters also opens the opportunity for its possible of deployment on a mobile launcher.

Japanese M-3 or M-5 Conversion

Though no more a threat to the U.S. than Israel, the Japanese have developed a family of solid fueled space launch boosters which could be copied by a belligerent Third World country or surreptitiously acquired through phantom companies. This assessment of a M-5 SLV capability to be used as an IRBM indicates the feasibility of the conversion of peaceful space boosters.

Options for LRBM Development
(Cluster/Stack Existing Missiles)

Two feasible LRBM designs were configured for this study based on existing TBMs: China's CSS-2 (2 stages, liquid) and China's M-9 (3 stages, solid). The use of existing missile subsystems to synthesize these two LRBMs is a logical approach based on proven subsystems from the two Chinese missiles. These highly proliferated TBMs represent likely building block options a Third World country might select. A country that has acquired or can produce SCUD-class missiles can cluster or stack them to achieve LRBM capabilities. However, to achieve ICBM-class ranges may require a new first stage.

The specific development option chosen would reflect on the country's development infrastructure and experience. Cluster/Stack design choices will be based on the preference for liquid or solid propulsion, the physical and operational requirements of the missile, and the engineering talent available for integration. A series of simulations were run to verify performance in flight and weight/payload/range characteristics of the two concepts presented. The industry study team applied proven missile design rules and a proven performance model to accurately synthesize these missiles using a clustering and stacking approach .

It is equally likely the development options presented here as distinct approaches may be varied to meet a specific country's technical requirements. For instance, a new-design liquid first stage based on an existing space launcher may be mated with the clustered or stacked boosters of a shorter range missile to achieve the required range. The feasibility of two approaches using the clustering and stacking technique is described.

Two Feasible LRBM Designs

Several Third World SRBM or MRBM rocket motors were considered as potential propulsion building blocks for a LRBM system. The two most feasible LRBM designs were found to be a two- stage ballistic missile employing clustered and stacked Chinese CSS-2 motors and a three-stage ballistic missile employing clustered and stacked Chinese M-9 rocket motors.

The CSS-2 ballistic missile design option (3 CSS-2 rocket motors clustered in the 1st stage and a single CSS-2 2nd stage) has a launch weight in excess of 250,000 kg. This large fixed-pad-launched LRBM is capable of deploying a 1000-kg payload to a range of 10,000 km with a 30-degree reentry angle trajectory. The smaller three-stage ballistic missile has a launch weight of 59,000 kg and is capable of deploying a 750-kg payload to a maximum range of 6,500 km.

Slight increases in ballistic missile range are possible with shallower reentry angles, but jeopardize payload integrity due to higher dynamic forces and heating at angles less than about 30 degrees.

Design Issues Considered in Assessment

This chart depicts the conceptual construct of a liquid fueled LRBM we have modeled based on the Chinese CSS-2. The design and fabrication of a missile system that will successfully deliver a payload to LRBM ranges must consider structural and integration factors not necessary for short range tactical systems. The launch weight of both cluster/stack LRBMs modeled includes increased inert weights for subsystems required to integrate the individual rocket motors. These inert items include the motor cluster truss structure, stacked rocket motor interstages, additional electrical and electronic subsystems and external protection provisions. No attempt was made to redesign or optimize the individual rocket motors other than adding an extendible nozzle exit cone to the booster upper stage(s).

With enough technical assistance and resources, a country could significantly redesign or develop an original LRBM design based loosely on a shorter range ballistic missile's technology. This study does not focus on such a radical and time consuming path, but rather presents a shortcut path likely to present the fewest technical obstacles and highest likelihood for success.

Range Sensitivity to Payload Weight

Off-nominal range performance for the two modeled ballistic missile designs can be attained by varying the payload weight or by lofting or depressing the nominal 30 degree reentry angle trajectory.
The clustered and stacked M-9 LRBM range performance can be varied between 8,000 km and 4,000 km by varying the payload weight between 500 and 1500 kg respectively.

Likewise, the clustered and stacked CSS-2 ballistic missile design can boost a 2,000-kg payload to ranges in excess of 8,000 km or a lighter 750-kg payload to over 10,000 km.

No attempt is made to project the precise payload configuration that may be developed by a Third World country. The range of payload weights portrayed here offer sufficient options for a country with a mission of political influence to deploy a "meaningful" WMD payload worth the expense of the ballistic missile's development.

Evaluation Methodology

A three-degree-of-freedom (3DOF) ballistic missile flight simulation model, AS-2530, was used to derive the performance capabilities (maximum range vs. payload) of several candidate missile configurations. The model employs booster propulsive and flight control properties, estimated overall aerodynamic drag characteristics and calculated vehicle stage weights with a simulated flight profile which includes launch, powered ascent, free-flight and reentry conditions. The conceptual missile performance capabilities presented were attained using AS-2530 assuming nominal launch, propulsion, flight control, staging and aerodynamic conditions during a ballistic trajectory.

The AS-2530 code is a 3DOF, point-mass flight simulation program capable of computing boost, free-flight and reentry trajectories for powered and unpowered vehicles. It employs a flexible flight plan with search procedures to permit predefined or maximum range performance simulations. The model has been used in-house at Boeing to perform quick, accurate performance evaluation of a number of U.S. and foreign weapon systems. Ballistic missiles assessed include: Minuteman, Peacekeeper and Midgetman ICBMs including growth options and operational configurations. The program has also been used to assess the performance capabilities of many Third World weapon systems from SRBMs to ICBMs and a variety of surface-to-surface, surface-to-air and air-to-air ballistic and cruise missiles

The two missile configurations described represent two of the successful booster/payload combinations chosen to depict Third World options that are capable of achieving LRBM ranges. The modeled flight characteristics presume nominal performance in all critical areas such as nominal ignition, predictable thrust, and programmed staging.

Similar or more sophisticated ballistic missile design or performance simulations should be available to Third World countries, many of which have access to western technology or computer analysis tools. Many Third World engineers and scientists have been educated in western universities. Likewise, Russian, Chinese, and North Korean computer codes are probably available which properly account for the flight mechanics and physics of LRBM flight.

Agenda

Numerous observations may be drawn from the report. The technology to construct crude long range ballistic missiles is available now. Recognition of this emerging threat should serve to galvanize our resolve to develop effective defenses against the threat of LRBMs from Third World countries.

Summary

The increasing number of countries possessing ballistic missile forces testify to the impotence of the voluntary Missile Technology Control Regime (MTCR) to significantly restrict the spread of technology.

As much as Third World countries want modern weapons, the world's hi-tech countries have demonstrated a corresponding desire to use technology enticements to gain influence and earn trade revenues. The politics of shifting spheres of influence in the post-Cold War, multi-polar world, are making for strange partners. Long range, rapid strike, and relatively great destructive power make ballistic missiles weapons of potent influence for governments willing to invest now to protect their statehood in the future. The military objectives that demanded the precision and reliability designed into Cold War ballistic missiles of the U.S., Britain, France, USSR, and later China may not be as relevant to Third World countries today. Political influence may be achieved by threatening to launch an inaccurate, unreliable ballistic missile armed with a chemical or biological payload at a population center. More importantly, the missile may also have the desired effect if not launched.

Given the high payoff in political leverage, a Third World government might make an investment in LRBM development deemed "unreasonably high" by U.S. standards. New innovative techniques will be used to shortcut development which may be difficult to detect or prevent. Third World progress toward a credible Third World LRBM capability is already underway.