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A RAND NOTE

The Impact of Missile Proliferation on U.S. Power Projection Capabilities

David Rubenson, Anna Slomovic

June 1990

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The growth in the numbers and capabilities of ballistic missiles outside Central Europe implies that non-nuclear ballistic missile threats, especially in combination with the growing capacity to produce chemical weapons, may pose an increasing threat to fixed U.S. overseas facilities and U.S. forces on rapid deployment missions. This Note addresses the proliferation of ballistic missiles with conventional warheads, including chemical warheads. Examining current ballistic missile arsenals reveals that they consist largely of inaccurate, short-range missiles, located mostly in North Africa and the Middle East. However, a geographically diverse set of countries are developing new missiles with improved ranges and capabilities, and this Note discusses the damage that can be inflicted by ballistic missiles armed with conventional munitions. Finally, the Note considers the chemical threat, demonstrating a correlation between countries that own ballistic missiles and countries seeking to develop a chemical weapons capability. The analysis shows that using even today's ballistic missile systems with chemical weapons could represent a major military threat for which the United States is relatively unprepared. Furthermore, the approaches for counteracting the chemical threat that are effective in Central Europe must be reevaluated and adjusted for the environment faced by U.S. forces in other areas of the world.

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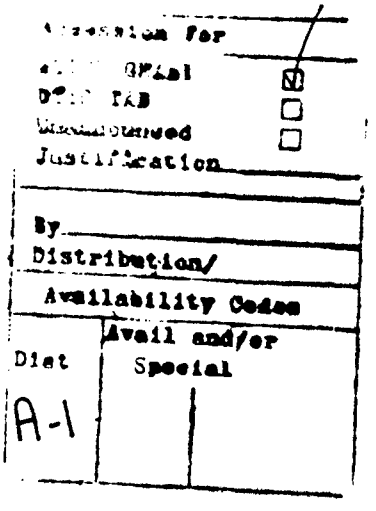

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PREFACE

This Note is based on briefings addressing the proliferation of ballistic missiles and chemical weapons in countries outside the European theater. The briefings discussed the threat ballistic missiles pose when combined with conventional or chemical weapons. The purpose of the briefings was to help focus attention in the defense community on the growing danger posed by the ballistic missiles threat outside Europe. The briefings were presented to Dr. D. Frederickson, Deputy Under Secretary of Defense for Acquisition, and to the Arroyo Center Policy Committee.

The work was jointly sponsored by the U.S. Army and the Deputy Director of Defense Research and Engineering/Tactical Warfare Programs. The research was conducted in the Applied Technology Program of RAND's Arroyo Center, and in the Force Employment Program of RAND's National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense.

This research is based on a synthesis of unclassified sources. All information used to develop this Note is publicly available.

SUMMARY

During the past decade, several countries outside Central Europe have acquired ballistic missiles of various ranges. U.S. concerns about short- and medium-range ballistic missiles have largely focused on developments within the European theater, or in connection with the use of ballistic missiles as a means for small powers to deliver nuclear weapons. However, the growth of the threat outside Central Europe implies that non-nuclear ballistic missile threats, especially in combination with the growing capacity for production of chemical weapons, may pose an increasing threat to fixed U.S. overseas facilities and U.S. forces on rapid deployment missions.

This Note is based on a briefing that addressed the proliferation of ballistic missiles with conventional warheads, including chemical warheads. In the first section of this Note, current ballistic missile arsenals are examined and shown to consist largely of inaccurate, short-range missiles. Most missiles are located in North Africa or in the Middle East. However, new missiles are being developed by a large number of geographically diverse countries. The ranges of these missiles are significantly greater than those in current arsenals, implying that more U.S. facilities could be threatened by future missile arsenals. U.S. rapid deployment forces may, in the future, face threats from a variety of sources in almost any strategically important part of the world. Although little is publicly known about the guidance and munitions technologies employed on missiles under development, moderate improvements in accuracies would not require use of advanced technology.

A more detailed determination of the damage that can be inflicted by ballistic missiles armed with conventional munitions is presented in the second section of this Note. It is shown that today's small arsenals have limited military effectiveness, although they may have potential for terror attacks. Growth in the size of missile forces, even with modest improvement in technology, may allow several countries to conduct limited but militarily significant attacks. Incorporation of moderate accuracy improvements, coupled with new munitions, would dramatically increase the military threat.

The final portion of this Note discusses the chemical threat. We demonstrate a correlation between countries that own ballistic missiles and countries seeking to develop a chemical weapons capability. The analysis shows that use of even today's ballistic

missile systems with chemical weapons could represent a major military threat for which the United States is relatively unprepared. Furthermore, the approaches for counteracting the chemical threat that are effective in Central Europe must be reevaluated and adjusted for the environment faced by U.S. forces in other areas of the world.

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I. INTRODUCTION

During the past decade the military arsenals of potential non-Warsaw Pact adversaries have grown in both size and technological sophistication. Most dramatic has been the growth of modern air forces. Air forces now provide many countries with the opportunities to strike targets well beyond their existing borders and suggest that U.S. forces could be vulnerable to attack when undertaking remote operations. Fixed overseas U.S. facilities have also come in range of potentially hostile air forces.

In recent years a new and potentially ominous expansion of this long-range threat has developed. Throughout the world nations have expanded their capability for long-range attacks through the acquisition of ballistic missiles. These missiles offer the potential for almost instantaneous attack at long distances. The absence of defenses against these missiles implies that they also provide a near-certain means of delivering a payload.

Many implications of ballistic missile forces have already been considered by military and political analysts. The implications of Soviet nuclear armed tactical ballistic missiles (TBMs) in the European theater have long been a major concern of NATO defense planners. In recent years there has been increased concern about the potential improvements in the accuracy of the missiles, allowing for the possibility of a Warsaw Pact conventional TBM capability. Numerous studies related to this possibility have been conducted and several recommendations brought forward. Another area of concern has been the possibility that ballistic missiles, if combined with nuclear weapons, might allow a small power to develop a long-range nuclear threat. The potential link with nuclear proliferation issues has been the major source of concern related to ballistic missile proliferation outside the European theater.

Concerns about the improved accuracy of Warsaw Pact ballistic missiles, and hence the conventional missile option, have brought attention to the ease with which ballistic missile accuracy can be improved. There are few technological obstacles for development of account ballistic missiles by non-Warsaw Pact countries. At the same time, events have raised concern about the proliferation of chemical weapons to non-Warsaw Pact countries. The use of chemical weapons in the Iran-Iraq war has demonstrated that the long-held reluctance to use these weapons may be eroding.

Ballistic missiles could represent an effective means of delivering such weapons even without improvements in missile accuracy.

RAND has performed studies on the impact of conventionally armed ballistic missiles on the progress of a conflict in Central Europe. These studies have indicated that while ballistic missiles provide an important capability, they may not provide a decisive military advantage. The effect of these missiles has been mitigated through the availability of passive defenses around potential targets, and through the reduction in the number of tactical ballistic missiles in Europe resulting from the Intermediate-Range Nuclear Forces (INF) treaty. As we will demonstrate, the conclusion that conventionally armed ballistic missiles do not provide a decisive military advantage is equally valid in other parts of the world. We will also demonstrate that when these missiles are combined with chemical weapons, their military impact would be quite different.

The potential for both a chemical and a conventional ballistic missile threat in regions outside the European theater raises a new set of questions. Although the use of chemical weapons has wide-reaching implications for the future of regional warfare, we examine a narrower issue in this Note. We will examine the impact of the changing environment on the U.S. military. Whereas air defenses could be counted on to effectively counter most non-Soviet air forces, ballistic missiles represent a new threat for which we have no defense. Both U.S. facilities and potential remote military operations may now be vulnerable to either chemical or conventional ballistic missile strikes. Adversaries may now have new military options that could previously be denied by effective defenses.

This Note is based on the vu-graphs and text from briefings on issues related to the chemical and conventional ballistic missile threat outside the central theater. We look at the scope and nature of the military threat and discuss its implications for the safety of overseas U.S. facilities and the ability to conduct military operations in remote areas. We also attempt to argue logically how and when hostile powers might choose to attack our assets with ballistic missiles. The purpose of this analysis is to help determine the scope of the threat, to examine how the Army and the Department of Defense should prepare to deal with it, and to examine the extent to which considerations made for NATO contingencies address the regional ballistic missile threat. Our intent is to focus attention on an aspect of the ballistic missile problem that has been partially obscured by concerns about nuclear missile proliferation.

II. THE WORLDWIDE BALLISTIC MISSILE THREAT

THE ROLE OF TACTICAL BALLISTIC MISSILES

The central question associated with ballistic missile proliferation is why a nation would choose to develop and acquire missiles when the option of delivering payloads by aircraft already exists. Aircraft that can be used more than once and can deliver differing types of munitions may be more attractive than missiles that can be used only once. Equally important is the question of why the missile threat represents any qualitative differences over those already posed by existing air forces.

Ballistic missiles add several important new dimensions to the threat. Missiles are a symbol of modern military power, seemingly providing a high level of prestige among developing nations. This prestige value appears to be almost independent of the missiles' accuracy or military utility. More tangibly, ballistic missiles also possess the military advantages of speed with which they can reach their targets and the assured ability to penetrate into enemy territory. Aircraft may take several hours to prepare and may require significant flight times. All this activity can be observed, and can provide warning to the target and the on-route defenses. Ballistic missiles can reach their targets almost instantly and with essentially 100 percent probability of penetration. In addition, missiles may put within range those targets that are beyond the range of combat aircraft.

At the moment, a nation's ability to use these advantages may be limited, particularly if large payloads are required. A ballistic missile might carry only several hundred pounds of payload and cannot be reused. If aircraft attrition rates remain at historical values of 1 to 3 percent, it is likely that aircraft will remain a more efficient method of delivering payload (assuming speed and assured penetrability are not critical factors). This cost disadvantage is likely to be greatest for countries just developing ballistic missile forces, as they also must acquire the necessary support infrastructure. However, it is possible that, as missiles proliferate and as countries build up their missile-support infrastructures, missiles will become progressively less expensive. The high cost of air force infrastructures, and the need for trained pilots to operate increasingly more sophisticated aircraft, may also lead countries that do not already have air forces to prefer ballistic missiles. If aircraft attrition rates greatly exceed historical values, missiles might also become the most cost effective means of delivering payload.

Ballistic missile use has attracted a great deal of recent attention as Iran and Iraq waged their War of the Cities. Although these missile firings seized world attention, there was little emphasis on the large numbers of missiles actually fired during the war (875 missiles, almost all of which were fired against cities).[1] Both sides started out with small missile arsenals, but obviously obtained additional missiles despite attempts to block weapons flow into the area. To our knowledge, all of the missiles used in this war were conventionally armed and used in terror attacks on opposing cities. Given their lack of accuracy and the lack of predictability of an impending attack, ballistic missiles are particularly suited as anti-population terror weapons. Although much attention has been given to the use of chemical weapons in this war, there is no evidence to suggest that chemically armed ballistic missiles were used.

During the Iran/Iraq war, fire rates were as high as 32 missiles per day, fired primarily by Iran. The low rate exhibited by Iraq probably indicates both a small number of launchers and the time-consuming preparation of missile launches. Oghab missiles fired by Iran are smaller, and may, therefore, be more easily loaded for refire.

The Iran-Iraq war is the most recent example of ballistic missile use. However, Soviet-built SCUD missiles were used during the 1973 Arab-Israeli war,[2] as were Frog rockets.[3] The missiles were fired by Syria and Egypt against Israel and apparently had little military effect.

CURRENT ARSENALS

Although previous use of ballistic missiles has not yet led to military success on the battlefield, many countries are continuing to build up missile arsenals. Figure 1 shows the worldwide distribution of ballistic missiles, omitting the United States, USSR, Western Europe, and China. The figure shows the numbers of launchers of various types believed to be located within nations. Launchers rather than missiles are indicated because the number of launchers is a limiting factor for the size of a simultaneous attack. Also, once the launchers and their support systems are in place, the marginal cost of missile attack falls dramatically.

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[1] W. S. Carus, *Missiles in the Middle East: New Threat to Stability*, The Washington Institute for Near East Policy, Research Memorandum No. 6, Washington, D.C., June 1988, p. 5.

[2] R. S. Ropelewski, "Israel Wary of High Technology Weapons Building in Middle East," *Aviation Week & Space Technology*, July 25, 1988, p. 44.

[3] W. S. Carus, p. 2.

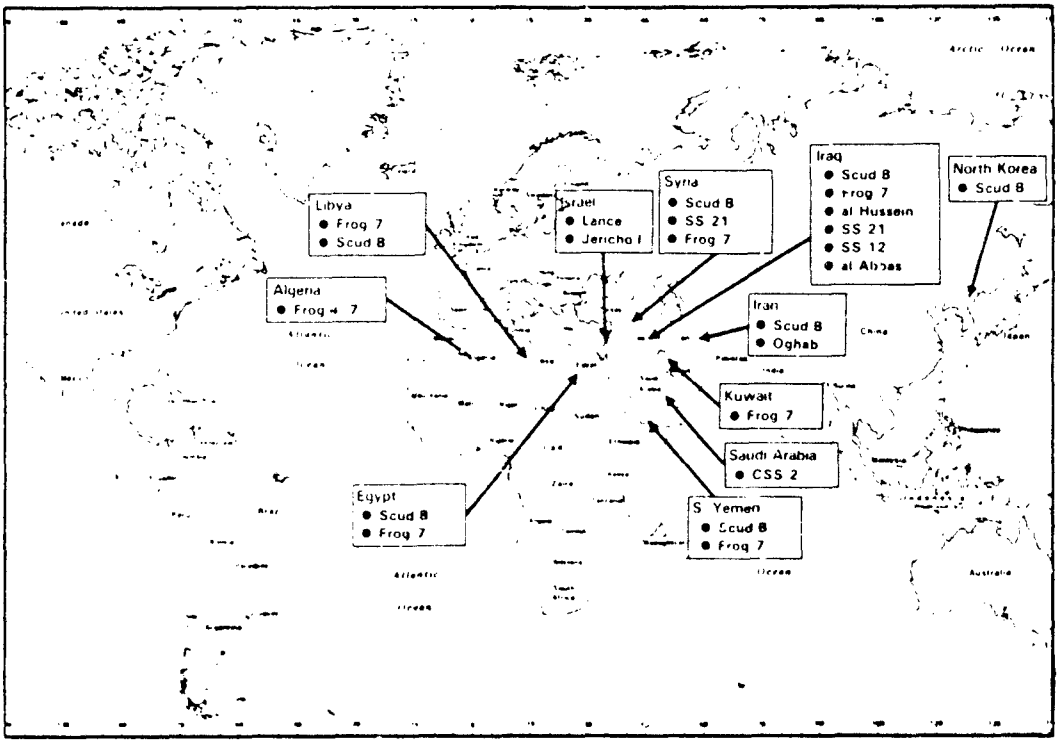

Fig. 1—Ballistic missile arsenals (launchers)

It is extremely difficult to obtain an accurate count of the missile airframes a nation might possess. Airframes are relatively small and easily hidden. Launcher counts are also subject to significant uncertainty. Many launchers are mobile and can be easily hidden and shifted among various locations. Also, launcher counts in countries like Syria fluctuate because Syria is used as a conduit for Soviet weapons sent to other nations in the region. The values shown in Fig. 1 are confirmed sitings, and therefore represent a lower limit on worldwide arsenals.

Most ballistic missiles outside the United States, USSR, Western Europe, and China are concentrated in the Middle East and North Africa. Some missiles are also located in North and South Korea. Most of these missiles are either Soviet-built Frog and SCUD missiles or derivatives of these missiles. The Chinese CSS-2 missiles in Saudi Arabia are a recent addition. The CSS-2 missiles are significant in that their range of approximately 3000 km represents the first acquisition of an intermediate range

ballistic missile (IRBM) by a non-nuclear power. India has just tested an indigenously developed Agni IRBM; in a development stage, the missile is not considered part of India's inventory. it is possible that as new Hades missiles enter French arsenals, the Pluton missile may be sold off fairly inexpensively, and the Middle East may be the final destination for these missiles.[4]

Figure 2 shows the known numbers of launchers for each of the countries in the Middle East and segregates them by range.[5] The vast majority of observed missiles have a range of less than 500 km. (The exceptions are the Saudi CSS-2s and Iraqi SCUDs, which have been modified for increased range.) It must be remembered, however, that

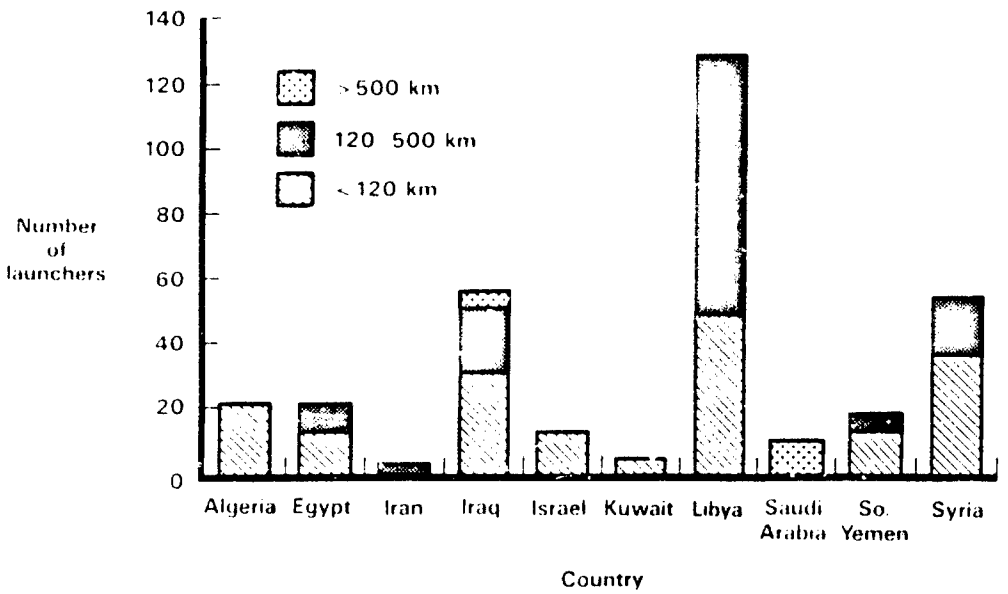

Fig. 2—Middle Eastern ballistic missile arsenals (lower bounds)

[4]The Pluton is a French land-mobile, vehicle-launched battlefield-support nuclear missile system. It has a range of 20–120 km. It is being replaced by the Hades surface-to-surface missile system with a range of over 400 km. [Jane's Weapon Systems, 1988–89, pp. 119–120.]

[5]This figure is a compilation of data from various open sources. See bibliography.

the distances between countries, and the proximity between cities and military installations in the Middle East, make some of these missiles strategic weapons.

Figure 3 demonstrates that the ballistic missiles in current arsenals are sufficient to cover most of the Middle East. Saudi CSS-2 missiles, which would cover the entire map, are not shown. The missile ranges are drawn as if the missiles were located on the country borders, although there is little indication of the true location of missile facilities. We assumed that mobile missiles could easily be placed anywhere in the country.

Figure 3 also indicates the major U.S. operating facilities in range of existing ballistic missile arsenals. These include Bahrain, which has become a key U.S. military logistical base and naval facility, and Incirlik and Ankara air force bases. These facilities could be attacked from Iraq by its longer-range missiles. In addition, if U.S. forces were to enter the Middle East through facilities in Saudi Arabia, these forces could be attacked by Iraqi missiles.

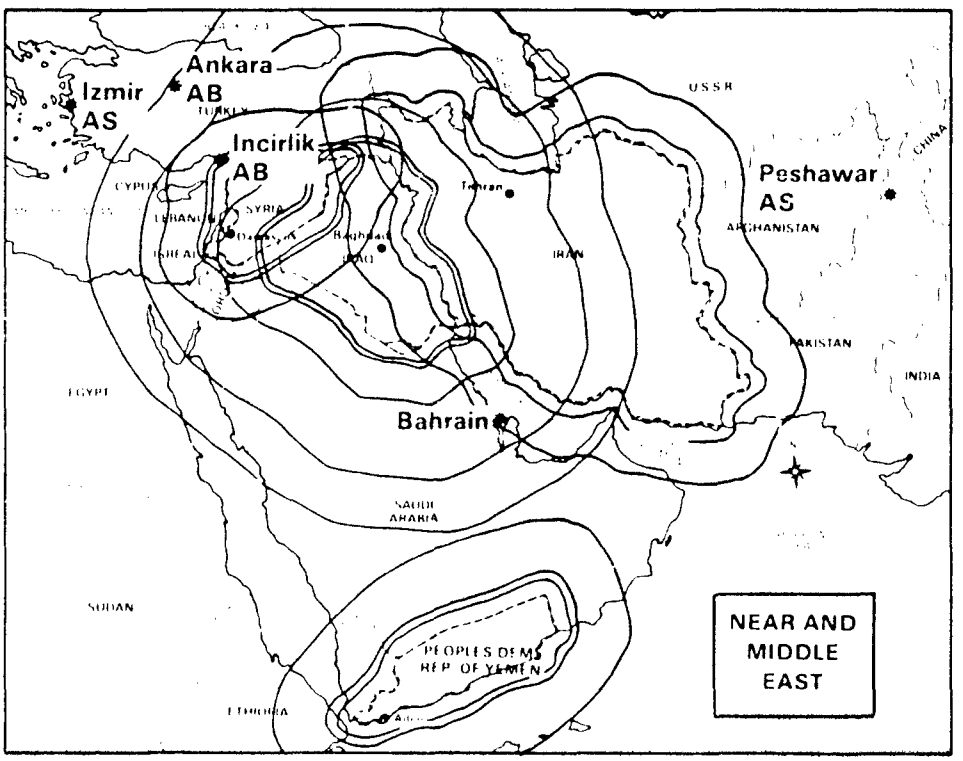

Fig. 3—Gulf region ballistic missiles

TRENDS IN MISSILE DEVELOPMENT

Perhaps more striking than existing ballistic missile arsenals is the pace at which the arsenals may increase in the future. Many new missiles are under development in different parts of the world. Ballistic missile development is considered to be a major national priority by Iran, Iraq, and Egypt. These countries have put significant resources into missile development both internally and in cooperative ventures with other nations, such as Brazil and Argentina. Some of the projects involve several nations. The 1000 km MB/EE, for example, is being developed by Brazil and Libya, with Iraqi funding, though most recent information indicates at least a temporary halt to this project; the Condor is being developed jointly by Egypt and Argentina; and a missile code-named Bader-2000 is being developed by Egypt and Argentina with Iraqi funding.[6] China is helping Iran build a factory to make surface-to-surface missiles with a range exceeding 500 miles.[7] Some nations are exchanging technology, rather than participating in joint development projects: China is supplying some of its missile technology to Argentina in exchange for use of that country's Antarctic research facilities.[8] Figure 4 reflects the assumption that the countries developing ballistic missiles will not only sell them to others but also build their own ballistic missile arsenals.

Different countries have experienced different degrees of success with their missile development projects. The People's Republic of China has become a major supplier of weapons, including ballistic missiles. The Xinhua News Agency reported a 96 percent missile launching success rate over the past five years, which they claim demonstrates reliability of Chinese missile systems.[9] On the other hand, it has been reported that eight Iranian missiles have blown up on the launching pad, causing casualties. A team of Syrian missile experts visited Iran in March 1988 to help the Iranians overcome their problems.[10]

Attempts have been made to prevent the spread of missile technologies from developed to developing nations. After four years of negotiations, a public

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[6]W. R. Doerner, "A Deadly New Missile Game," *Time*, July 4, 1988, p. 38. More recent reports indicate the joint Libya-Brazil program has run into severe problems.

[7]"China Is Helping Iran To Build Missile Plant, Sources Said," *Baltimore Sun*, March 9, 1989, p. 4.

[8]L. Branson, "Argentina in Missile Deal," *London Sunday Times*, May 22, 1988, p. 19.

[9]"China/Missile Launching," *International Media*, June 10, 1988.

[10]"Syria/Iranian Missile Bases," *International Media*, April 18, 1988.

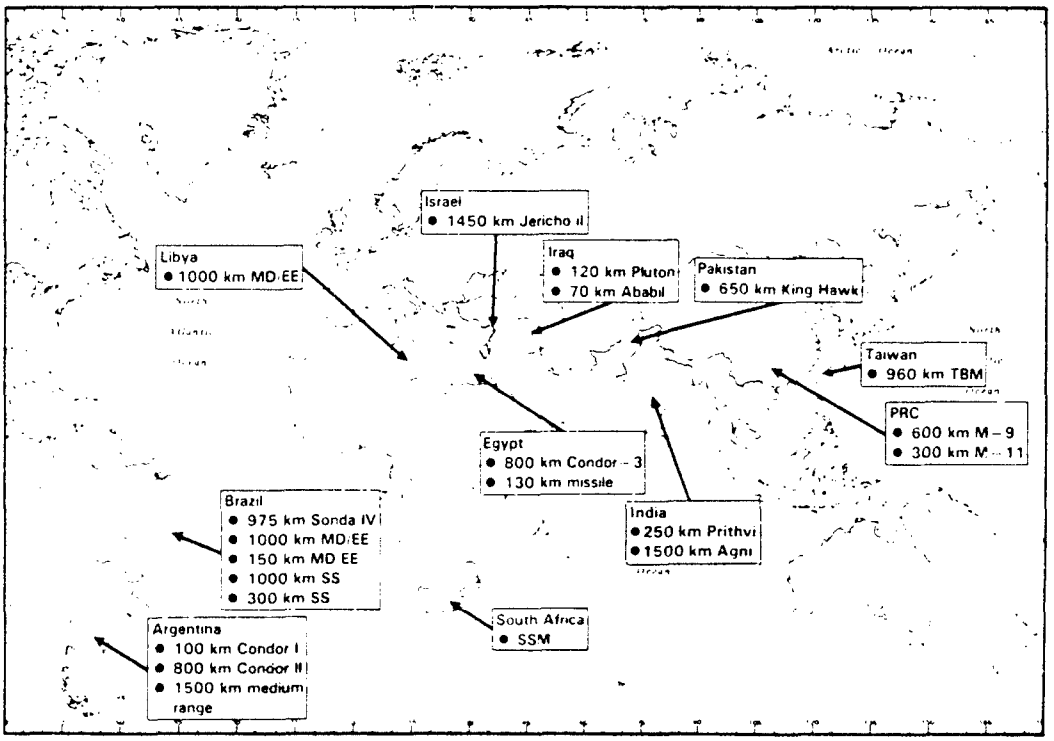

Fig. 4—Missile development projects

announcement was made on April 16, 1987, in which the participants (Canada, France, the Federal Republic of Germany, Italy, Japan, the United Kingdom, and the United States) agreed not to sell complete rocket systems, subsystems, production equipment and facilities, or design and production technology that could be used to create unmanned capability to deliver 500 kg to 300 km. The capability is included regardless of name (space launch vehicles, drones, ballistic missiles, etc.), and includes old as well as new technology.[11] Obviously, based on the above information, this may be too little too late. The nations most interested in acquiring and developing ballistic missiles are not part of the regime, and are busily building missiles based on the technology already in the field.

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[11]"Missile Technology Control Regime Announcement by the White House," and accompanying fact sheet and public statement by the Department of State, April 16, 1987.

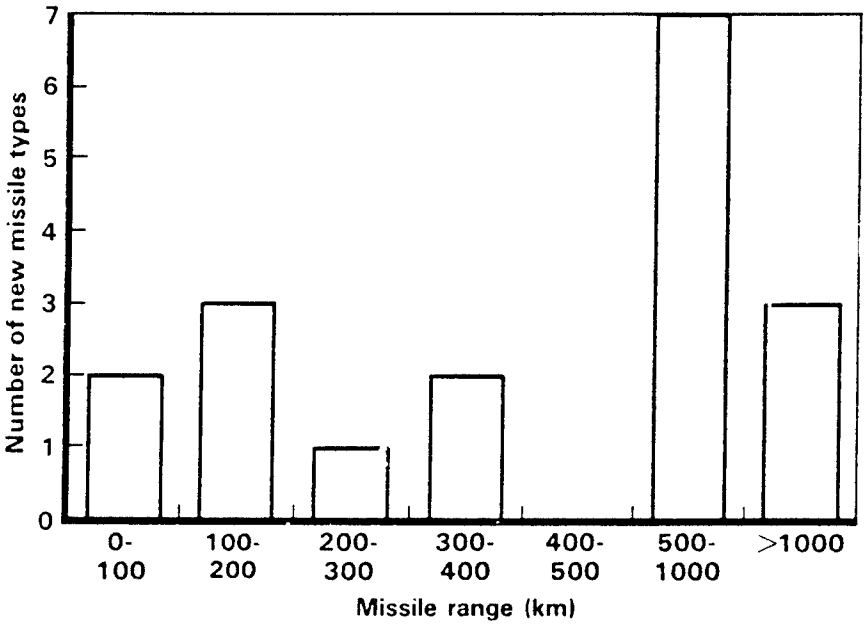

Fig. 5—Missiles under development

Most of the development projects are concentrating on missiles with greater range than those in existing arsenals. Figure 5 shows that a majority of the missiles under development are well above the range of the 300-km SCUD that makes up most of today's long-range potential. The most recent illustration of this was a test firing of a 1500-km missile by India this May.[12] As the number of long-range missiles increases, and as the number of countries possessing such missiles rises, the number of potential participants in any conflict increases as well.

THREATS TO U.S. FACILITIES

Figure 6 shows the number of U.S. facilities in Italy, Spain, Greece, and Turkey, the number that could be threatened by today's missile arsenals, and the number that could be threatened if the countries developing new missiles incorporate these missiles

[12]See, for example, Richard M. Weintraub, "India Tests Mid-Range 'Agni' Missile," *Washington Post*, May 23, 1989, p. 1.

into their arsenals.[13] It is seen that only a few U.S. facilities are threatened by current ballistic missile arsenals. However, as projects under development come on line, and as ranges increase, more of these facilities come under threat. Even without considering the missile threat, the fate of some U.S. facilities in Greece is uncertain: Hellenikon Air Force Base is to be closed, and the fate of several other installations is in dispute. Until their new location is known, their vulnerability to ballistic missile attack cannot be evaluated, but consideration of such vulnerability should be a factor in selection of the new site. The U.S. Army's facilities, located in northern Italy, are not threatened by the ballistic missiles currently under development.

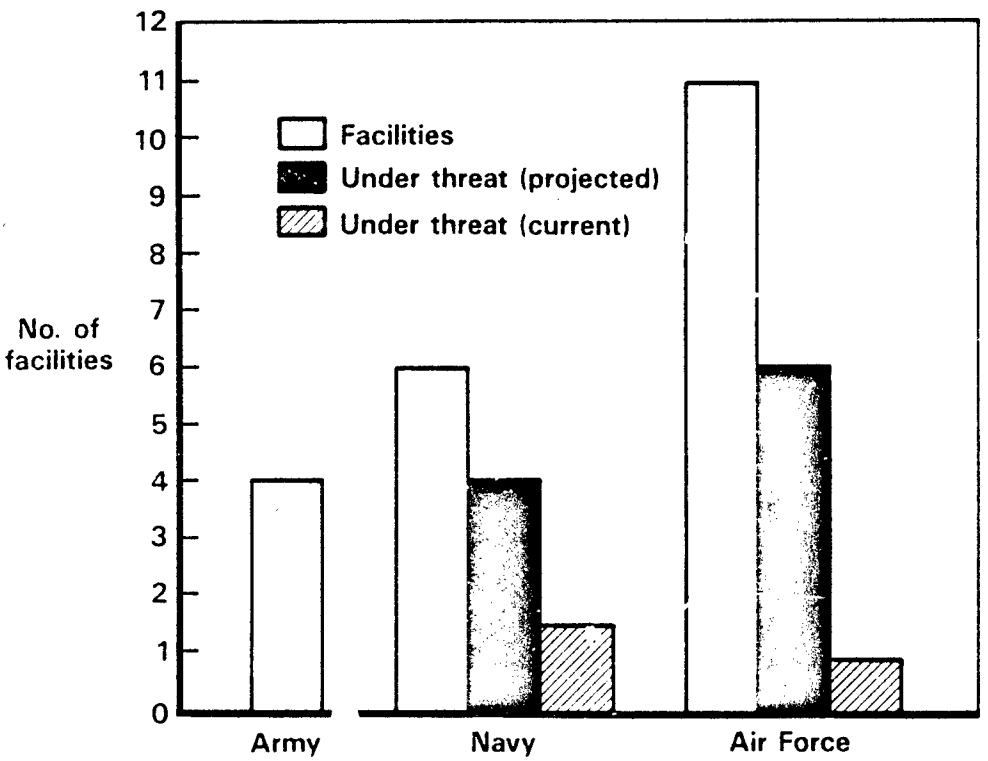

Fig. 6—U.S. Mediterranean and Middle East facilities

[13]The information was compiled from the *U.S. and World Military and Government Installation Directory Service*, La Jolla, CA, 1986 edition, and other open sources.

Figure 7 provides a dramatic example of the implications of the new missile developments. Earlier charts indicated that Libya already possesses a large number of ballistic missile launchers for short-range missiles. The nation is also actively engaged in attempts to acquire longer-range missiles. Libya's attempt to use ballistic missiles against U.S. facilities was unsuccessful because of limited range and accuracy. Its current arsenal cannot reach most U.S. facilities in the Middle East. However, should Libya succeed in its attempts to acquire longer-range missiles, those missiles could pose a threat to U.S. facilities in the region. This threat includes not only conventional warheads but also chemical warheads. The chemical plant at Rabta recently received media attention. Libyans have claimed that the Rabta plant is intended for the production of pharmaceuticals, but the U.S. government has openly stated that the plant may be intended for the production of chemical weapons.

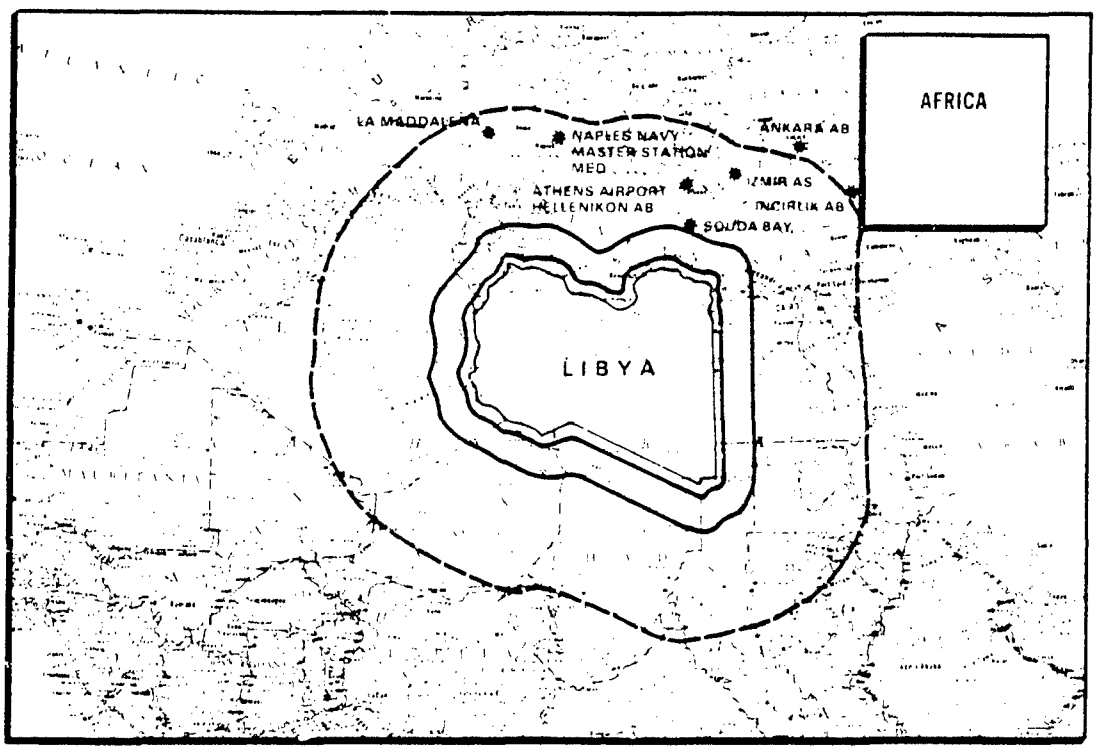

Fig. 7—Libya: current and future ballistic missiles

So far, Libyan efforts to acquire long-range missiles have not been successful. Both the Soviets and the Chinese have refused to sell longer-range ballistic missiles to Libya. The United States has actively discouraged Argentina and Brazil from collaborating with Libya on missile development projects. However, should the 1000 km MB/EE missile eventually be developed, Libyan missiles would have the coverage indicated in the figure.

MISSILE TECHNOLOGY

Figure 8 summarizes the current state of missile technology and the improvements that may be expected. Missile accuracy is a critical attribute. When missiles are considered purely as nuclear delivery systems, accuracies are not particularly important. Accuracy is more important for chemical weapons, although in this case weather conditions may have more influence on the ability to properly disperse chemicals than does the accuracy of the delivery missiles. Accuracy is most important for conventionally-armed ballistic missiles—inaccurate conventional missiles may offer the

- **Current TBMs have:**
  - **Unitary conventional warheads**
  - **~300 m CEP or greater**
- **Current technology may allow for:**
  - **Cluster munitions (Egyptian experiments)**
  - **~100 m CEP (improved inertial guidance)**
  - **Chemical warheads**
- **Advanced technology would be required for:**
  - **<50 m accuracy**
  - **Smart munitions**

Fig. 8—Ballistic missile technology

potential to cause significant terror or disruptive effects, but cannot provide a guaranteed level of damage to a military target unless large numbers of missiles are used.

Today's ballistic missiles are inaccurate for effective nonnuclear use of all ranges, except for a small number of the shorter-range SS-21s provided by the Soviets to Syria.[14] It is clear, however, that development of improved accuracies will be a priority for missile developers if they hope to develop militarily effective ballistic missiles. This improvement in accuracies may be accomplished with improved inertial guidance, within current technology.

All missiles that have been fired in military operations have possessed unitary warheads. Many analyses have considered the possibility of arming Soviet ballistic missiles with submunitions. There are reports that the Egyptian Sakr-80 rocket can deliver cluster munitions and minelets.[15]

The threat posed by the proliferation of ballistic missiles is real and growing. Most certain appears to be the growth in the number of countries that will possess ballistic missiles, the geographical diversity of these countries, and the increased ranges of the missiles. This implies that U.S. fixed facilities will in the future be threatened by an increasing number of countries. U.S. remote military operations will become subject to a wide range of threats that may originate at sources far from the operational area.

Less clear are the current patterns in military technology and missile accuracy. Although improvements in accuracy can be achieved with widely accessible technology, there are many uncertainties involved in the development of highly precise ballistic missiles. The interaction between munitions deployment and guidance, and the lack of observations regarding the testing of new munitions, suggests that the development of a highly refined conventional TBM threat may be many years away.

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[14]W. S. Carus, p. 3.

[15]W. S. Carus, p. 5.

III. CONVENTIONAL ATTACK SCENARIOS

We will next examine the implications of the TBM threat in conventional attack scenarios. Uses for conventionally armed ballistic missiles have been extensively explored in NATO scenarios. These analyses show that ballistic missiles would be most effective when used in conjunction with air attacks on NATO airfields. Highly accurate tactical ballistic missiles would cause a disruptive effect on airfield operations, allowing time for Warsaw Pact fighter bombers to arrive and inflict l. ;ge-scale damage.

However, U.S. interests are not limited to Central Europe, as reflected in the worldwide operations the Army must be ready to undertake. Figure 9 illustrates a potential scenario the Army considers in its planning guidelines. In this Note, we will consider a generalized Middle East scenario as a means of illustrating the implications of tactical ballistic missiles.

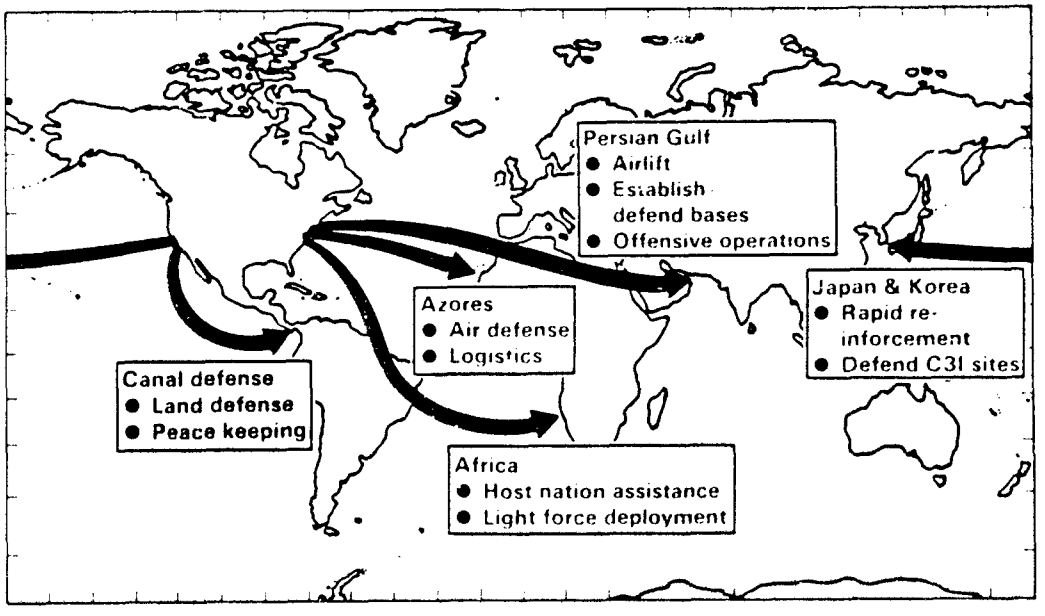

Fig. 9—Some regional Army missions in "Air-Land Battle Future"

A GENERALIZED SCENARIO

In the Middle East and other regions, we might expect ballistic missiles to be used against both fixed facilities and rapid deployment forces employed in crisis. They could also threaten U.S. forces engaged in cooperative use of APODs and SPODs. Denial of such facilities could significantly slow U.S. projection forces.

A typical deployment scenario for the Middle East is described in Fig. 10. We assume an airlift operation to a civilian airport where we have the cooperation of local authorities. We further assume that a variety of force structures will be involved. These units will assemble in a nearby area awaiting orders for movement to a combat area. This scenario is one of many possible variations and will be used only as a basis for a first-order discussion of the military implications of TBM proliferation.

APPLICATIONS OF CONVENTIONALLY ARMED MISSILES

One possible use of large unitary warheads is to crater roads that are critical for use by the rapid deployment force scenario postulated in Fig. 10. Figure 11 shows the probability of cratering a road using unitary warheads and 300 m CEP missiles.

- **Airlift a brigade to a Middle Eastern airport**
  - **Armor**
  - **Air defense**
  - **Troops**
  - **etc.**
- **Assemble near the airport**
- **1-2 days delay awaiting orders**
- **Move to nearby combat area**

Fig. 10—A regional conflict scenario

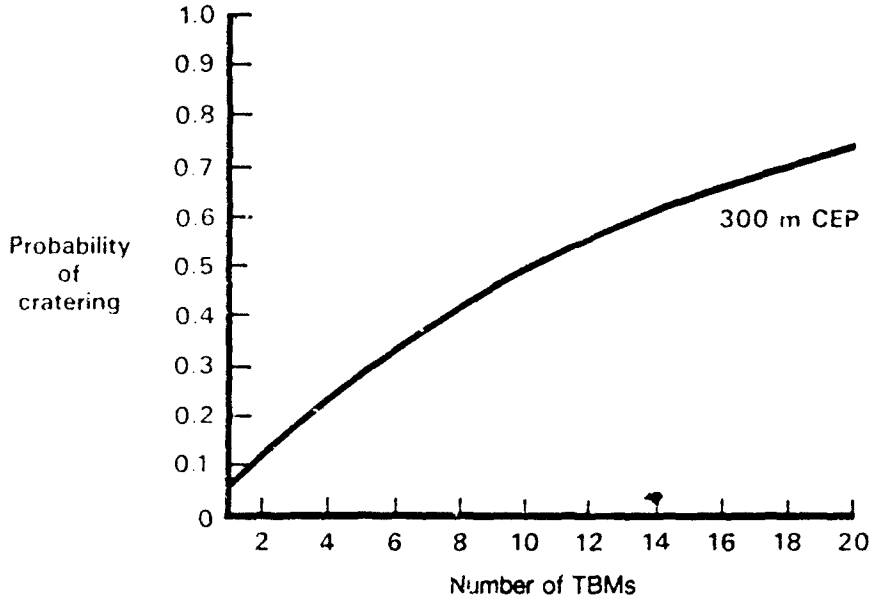

Fig. 11—Probability of cratering a road (unitary warhead)

The effectiveness of such attack is highly dependent on the scenario and specific topography. A road cratered on a flat plain might easily be bypassed. A road cratered in mountainous country, such as the Sinai, might be a highly effective means of blocking troop movement. In such a case it may not be necessary to score a direct hit on the road, as assumed in the above calculations. Damaging nearby rock formations could lead to slides or other effects that make such a road impassable.

Perhaps the most vulnerable portion of the scenario postulated in Fig. 10 is related to operations at the airport of embarkation. A civilian airport would provide little protection.

Figure 12 shows that transport aircraft parked in the open might be vulnerable to attacks from TBMs. The figure shows that submunitions are required for effective attack. The large unitary warheads and the poor CEPs that characterize existing TBMs are not capable of effectively attacking aircraft in the open.

Given ballistic missiles with the accuracy of the SS-21 and the assumption of submunitions, there is almost a one-to-one tradeoff between the missiles fired and damaged aircraft; as accuracy degrades, the tradeoff becomes worse from the point of view of the attacker. However, the possibility of damaging highly visible and important

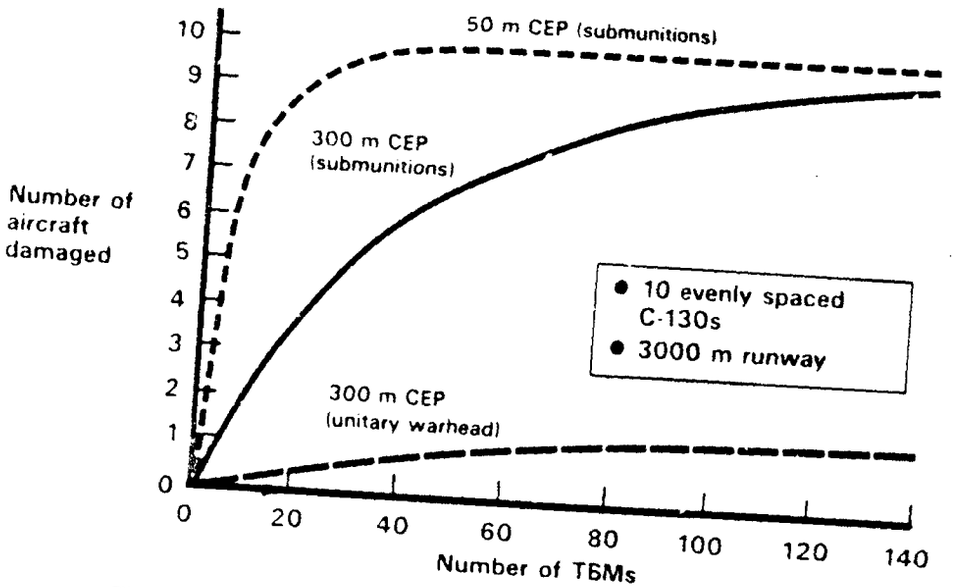

Fig. 12—Ballistic missiles against parked aircraft (submunitions)

U.S. assets might motivate a potential attacker. It is also noted that Fig. 12 records only damaged aircraft and does not reflect the chaos and debris that would result from a missile attack.

A more effective alternative to cratering roads with large unitary warheads is to use missiles to lay mines. Many small mines might easily be placed on a missile. The calculation that led to Fig. 13 conservatively assumes only 150 such mines per missile. The figure shows that even inaccurate missiles can place some mines on roads. The relative insensitivity to accuracy is a result of deploying mines in a large geometrical pattern. This suggests that even zero CEP ballistic missiles will place only a limited number of mines on a road.

As the number of ballistic missiles around the world grows, so does their ability to threaten or harass U.S. overseas facilities. The present-day threat is composed mainly of missiles with poor accuracies and unitary warheads, more suitable for terrorizing urban populations than attacking military targets. Improved accuracies and the use of submunitions would increase the threat. The threat of inaccurate missiles used in large numbers for effective attack appears to be growing. The combination of arsenal growth and moderate improvement in missile accuracy would change the character of the military threat posed by several national ballistic missile arsenals.

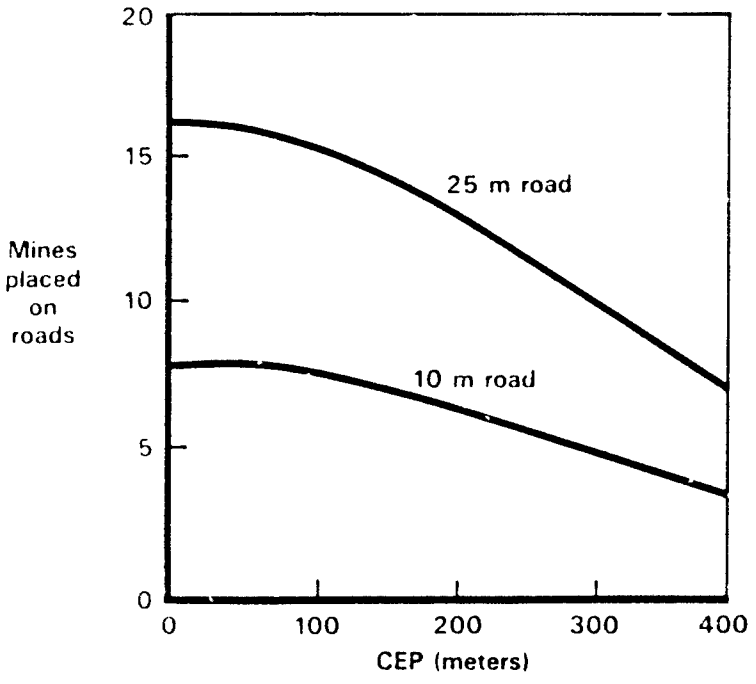

Fig. 13—Mining roads with ballistic missiles (150 mines/missile)

IV. CHEMICAL ATTACK SCENARIOS

In this section of the Note, we consider the potential of chemically armed ballistic missiles. A disturbing recent development is the proliferation of chemical weapons (CW). Smaller nations seem increasingly interested in acquiring chemical weapons, perhaps because of the long-standing obstacles to acquisition of nuclear weapons technology. The nonnuclear nations may view the acquisition of chemical weapons and the means for their delivery as a way of countering the nuclear capabilities of their adversaries. Figure 14 shows that there is a high degree of correlation between ballistic missile and chemical weapons acquisitions. There are few countries with ballistic missiles that are not seeking to develop a chemical capability and only a few countries with chemical weapons not developing a ballistic missile capability (not shown in the figure).

	CW Status		
Country	Force Size (launchers)	Thought To Possess or Close	Not Actively Seeking
Libya	132		
Iraq	>56		
Syria	>54		
Egypt	>21		
Algeria	20		
S. Yemen	>18		
Israel	12		
Saudi Arabia	>10		
North Korea	7		
Kuwait	4		
Iran	>3		
Total	>329	>285	>44

Fig. 14—Correlation of ballistic missile and chemical threats

Israel has discovered that Syria has developed special warheads for its SS-21 and SCUD missiles to launch nerve gas.[1] The warheads are based on technology supplied by the Soviet Union and Czechoslovakia. It has been reported that the first chemical warheads were loaded and fielded in early 1988.

Although Iraq is the only country to have acknowledged the use of chemical weapons (against their own Kurdish population, delivered by aircraft), several others have been strongly suspected of having the capability.

POTENTIAL MILITARY EFFECTIVENESS

Figure 15 compares the areas that can be attacked by differently armed ballistic missiles and indicates that the military threat posed by chemical missiles may be of vastly different magnitude from that posed by conventional missiles. Although it is difficult to draw analogies between the effects of chemical and explosive weapons, the areas shown

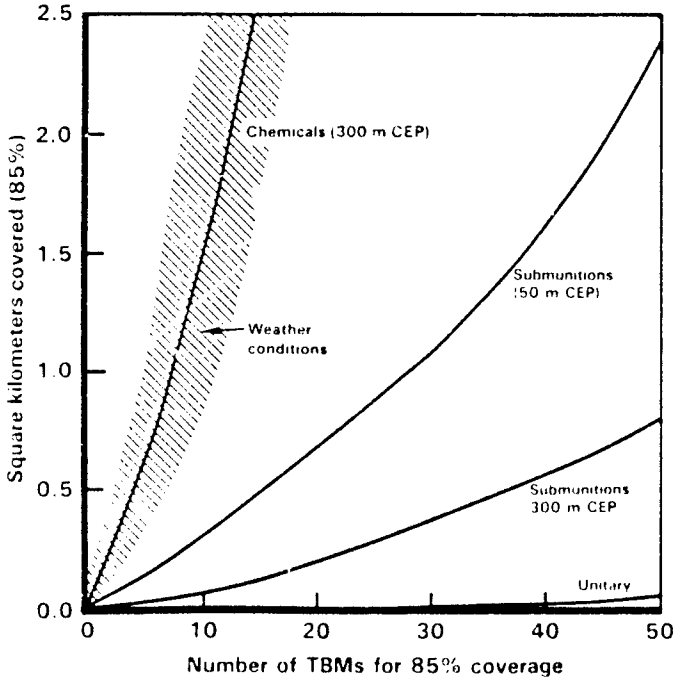

Fig. 15—Weapons effectiveness comparisons

[1]No byline, "Soviet Chemical War Chief Alerts West with Syria Visit," *Washington Times*, April 8, 1988, p. 9.

in the figure are based on lethality to unprotected human beings. The figure shows that militarily effective conventional ballistic missiles will require advances in warhead and guidance technologies. However, effective chemically armed ballistic missiles could already exist and would have a potentially greater impact.

Two factors play a role in explaining these curves: missile accuracy and footprint of the munitions used. Submunitions are assumed to produce a lethal circular area with a 300 ft diameter. More accurate missiles with submunitions are more efficient than less accurate ones because of avoidance of overlapping coverage. However, this lethal area is still small compared with the coverage provided by chemically armed ballistic missiles. The lethality provided by chemically armed missiles is largely insensitive to CEP. Even an inaccurate ballistic missile with a chemical warhead (a weapon within current capabilities) provides better coverage than a reasonably accurate missile with submunitions. The largest uncertainty surrounding the coverage provided by chemically armed ballistic missiles is associated with weather conditions, and this is notionally shown by the band around the curve for chemical weapons.

Chemically armed ballistic missiles can be used against the same kinds of targets as conventionally armed missiles. However, as Fig. 15 shows, chemically armed missiles may be much more effective when unprotected personnel are critical to the viability of the target. Chemical weapons may represent a particularly effective threat against rapid deployment forces. To protect themselves from chemical attack, troops would have to be equipped more heavily and be specially trained. Since operations in chemical gear are more difficult than operations without it, anti-chemical precautions may introduce significant delays into deployment. If precautions are not taken, however, chemical weapons could completely disable the force.

The proliferation of a worldwide chemical ballistic missile threat could pose new challenges to our forces and to those devising counters to chemical weapons. Meteorological conditions are critical both to the employment of chemical weapons and to defenses against them. Current defense efforts have been largely directed toward Central European scenarios, where meteorological conditions allow use of persistent agents, but water is available for decontamination, and air temperatures may be cool enough to wear protective gear.

The environment in the Middle East is significantly different. Hot, dry weather decreases the persistence of dispensed chemicals, but there will be little water for

decontamination, and wearing chemical protection gear may be intolerable. Thus, the chemical ballistic missile threat in the Middle East involves tradeoffs and issues that cannot easily be inferred from analyses of the European theater. The same is obviously true for other regions where region-specific factors will affect both the severity of the chemical threat and the feasibility of countering it.

Figure 16 shows the laydown of chemically armed ballistic missiles over an airport, similar to that assumed in the deplaning scenario shown in Fig. 10. Four missiles could cover the entire landing area with a potentially lethal dose to unprotected personnel. If perfect coverage is required, and the missiles have poor launch reliabilities, it may require as many as 10 to 15 missiles to obtain the coverage shown in Fig. 16. However, it is also possible that complete coverage would not be necessary if ballistic missiles were used to harass and slow down operations: the presence of chemicals anywhere on the base is likely to send everyone into protective gear and seriously impair operations. Depending on the goal of the attacker, such impairment may be sufficient.

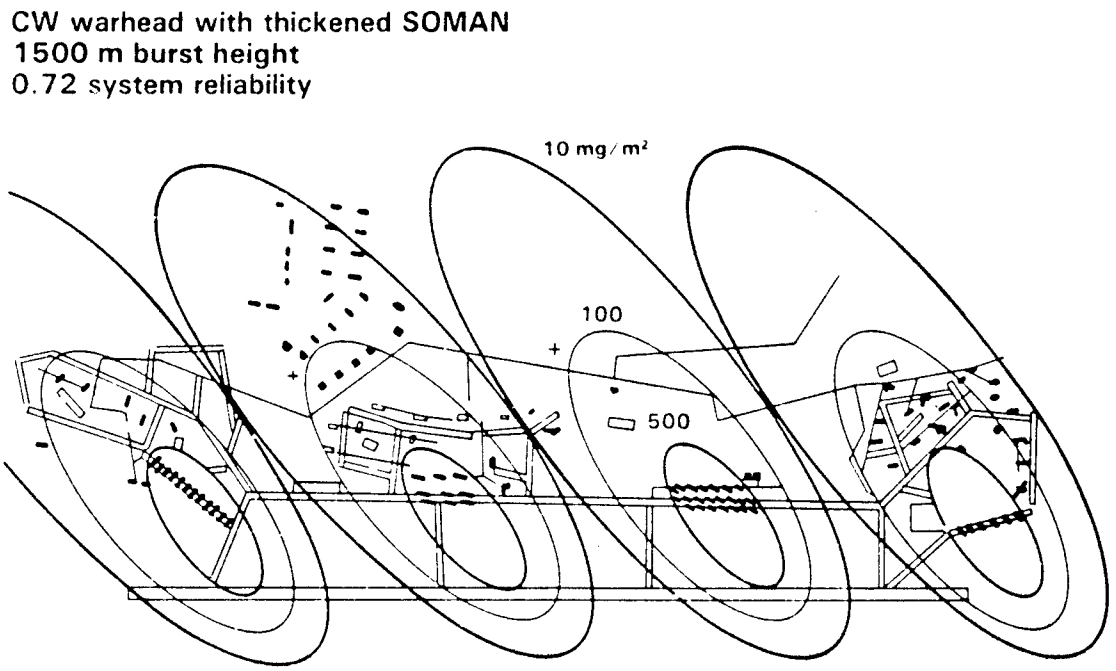

Fig. 16—Chemical attack on deplaning troops

Figure 17 shows the number of chemically armed ballistic missiles required for an effective attack against a variety of targets that might be relevant to the scenario presented in Fig. 10. A compact target, like an artillery battery, can be covered easily with a few missiles. On the other hand, the area covered by a brigade in an assembly area requires many missiles. However, if the brigade were in range of Libyan or Iraqi TBM arsenals, a significant portion of the brigade could be destroyed unless protective actions were taken.

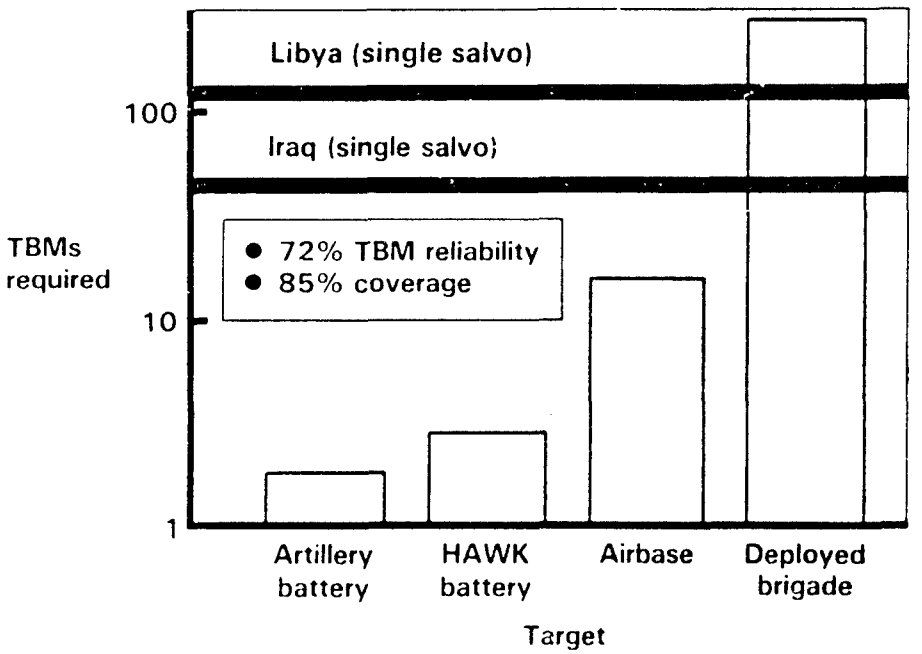

Fig. 17—Target vulnerability

V. POTENTIAL RESPONSES

Present-day ballistic missile arsenals with poor accuracies and unitary conventional warheads have the potential to harass U.S. military facilities and operations abroad. Today's non-European missile arsenals do not possess sufficient accuracy to constitute a significant military threat with conventional weapons, but the threat of chemical weapons combined with ballistic missiles could represent a real military threat with few advances in technology.

Trends in threat development point to several disturbing factors. Missile ranges are getting longer and more countries are acquiring ballistic missiles. U.S. assets will thus be within range of an increasing number of missile arsenals. In addition, as the number of producers grows, the prices of missile airframes may be expected to fall, making more attractive the use of more missiles per mission. Our calculations show that even if there are only marginal advances in munitions and guidance technology, some militarily important missions could be conducted by using large numbers of ballistic missiles. Such numbers do not appear to be inconsistent with the rate of growth of missile proliferation.

Another serious development is the progression toward increased missile accuracies, especially when combined with new munitions. Such missiles are not currently available in large quantities, but the necessary technologies do not require great innovations, and it is logical to assume that their numbers will increase with time.

Current ballistic missile arsenals adapted to carry chemical weapons would represent a significant military threat. When combined with the expected growth in ballistic missile accuracy, missile range, and the number of countries seeking to obtain chemical weapons, chemically armed ballistic missiles could represent a major threat to U.S. operations anywhere in the world. They could become a more serious problem than the threat of nuclear-armed ballistic missiles.

A number of responses to ballistic missiles have been considered in the European scenario. In this section, we examine these responses in light of their applicability in non-European scenarios. It should of course be remembered that the ultimate actions taken are likely to be a combination of responses. The following discussion reviews

defensive techniques in an isolated fashion, without incorporating defensive synergies that must ultimately be included in any definitive analysis.

Three types of defenses are possible against both aircraft and missiles: active defense, passive defense, and counterforce/preemption.[1] Figure 18 summarizes some of the features possessed by aircraft and ballistic missiles, and the impact of those features on the feasibility of different types of defense against the weapons. The differences in characteristics of missiles and aircraft point to the greater difficulty of defending against missiles—missile launch sites are mobile (as opposed to fixed airbases), and they arrive without warning. And, as discussed in the text, the ranges of TBMs are beginning to exceed the operational range of many non-European air forces. U.S. forces have anti-aircraft batteries that can be deployed, but no portable defenses against missiles exist.

Options for defense against TBMs include passive options, active defense, counterfire against TBM launches, arms control, and formulating policies that might

Options	Aircraft	TBMs
Active defense	Mobile SAMs	Limited*
Counterforce	Fixed airbases	Mobile launchers
Passive defense	$\geq$ 30 min warning	No warning
Range of potential adversaries	$\leq$ 500 km	$\leq$ 1000 km+

*Limited ATBM capability can be provided by the HAWK system and the PAC-1 and -2 Patriot upgrades.

Fig. 18—Countering ballistic missile and aircraft threats

[1]In this context, arms control and deterrence are not considered as defenses. These approaches to dealing with the ballistic missile threat are considered below.

deter such attacks. Although we have not arrived at recommendations as to which approaches are most attractive, the following brief discussion will illustrate how the factors influencing each technique will depend on the region, scenario, and country involved and may be in direct contrast to the factors influencing the choices in a European scenario.

The feasibility of using passive defenses to mitigate the effects of chemical attacks will depend on the aspect of the scenario. As Fig. 19 shows, when forces are engaged in armored combat, the filtration system should provide adequate protection. The vehicles would provide movement away from the toxic region and decontamination would not be immediately necessary.

For forces in assembly areas, infantry combat, or deplaning, there is greater difficulty. It is clearly impossible to move safely from the attacked area. Personal kits will allow minor decontamination, whereas major decontamination requires large quantities of water. Protection is dependent on personnel wearing protective (MOPP) gear.

Figure 20 shows that MOPP gear may not be an effective option for Middle East scenarios. The gear is bulky and is not efficient in dissipating body heat. Soldiers wearing such gear are not able to function effectively, although the degree of effectiveness can be improved with training. The gear's inability to dissipate body heat may lead to heat exhaustion and complete function impairment. Figure 20 shows, for

Force operation	Protection	Avoidance	Decontamination
Armored/fighting vehicle operations	Filtered vehicles	Filtered vehicles	Not required
Landing/infantry operations	Protective suits (MOPP)	?	• Personal kits • Sanators
Logistics/assembly	Protective suits (MOPP)/secured tents	?	• Personal kits • Sanators • Water intensive procedures (500 gallon tank)

Fig. 19—Today's passive defenses

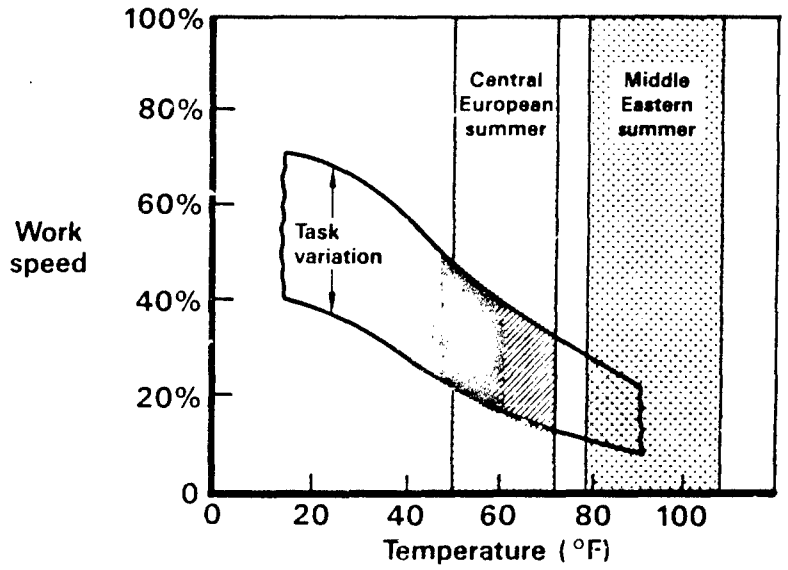

Fig. 20—Tank maintenance with MOPP gear

example, that the impact of MOPP gear on the ability to perform tank maintenance tasks is severe even in the cold weather of the European winter. It is an open question as to how long and effectively troops in MOPP gear could perform in the conditions of a central European summer. In the heat of a Middle Eastern summer, operation in MOPP gear is not a viable alternative.

Our studies have indicated that active defenses may play a limited role in helping to mitigate the TBM threat in Europe. In the European scenario, the objective was to intercept conventionally armed ballistic missiles with ranges less than the limit provided by the INF treaty. The treaty reduced the range and hence speed of incoming TBMs. This reduced the technical demands on anti-tactical ballistic missile (ATBM) systems. On the other hand, the design of active defense systems for non-European scenarios may be more difficult. The factors increasing the obstacles for active defenses are summarized in Fig. 21. Longer-range missiles will be faster than those that would be anticipated in Europe, and hence larger, more expensive ATBM systems will be required. Such missiles are also more likely to carry chemical weapons, implying maintenance of larger keep-out zones, greater radar size, larger interceptors, and more sophisticated homing systems. In a regional scenario such systems must be transportable.

- European scenario
  - Limits on threat provide opportunity for ATBM
    - Conventional warhead (3 km keep-out zone)
    - INF treaty (≤2 km/sec speed)
    - 0-75° threat azimuth
  - Utility is limited by ATBM costs and performance
- Regional scenario
  - Larger, more expensive ATBMs may be needed
    - Chemical warheads (>10 km keep-out zone)
    - Long-range TBMs (>3 km/sec)
    - 360° azimuth
  - The system must be portable

Fig. 21—The feasibility of active defense

Counterfire, i.e., attacking launchers or reload sites before the attacker can expend his complement of missiles, has been examined in the European scenario, and is generally considered not to be promising. As Fig. 22 shows, dense terrain, efficient Soviet missile operations, and thick Soviet air defenses make search for mobile launchers difficult. Terrain in the Middle East is more open and may allow greater use of satellites and aircraft for precision search. Although we have not conducted a thorough study, it appears that the key obstacles for a counterforce system in Europe may not be present in the Middle East. We therefore recommend that this option be studied in more detail.

Two other approaches for limiting the ballistic missile threat involve arms control and formulation of deterrence policies. Currently 40 countries are participating in negotiations in Geneva on limitations on chemical weapons. Some have argued that both the United States and the Soviet Union have strong political incentives to reach an agreement. However, the participation of countries outside Europe is minimal and the Geneva negotiations could lead to the perception that significant progress on chemical arms has been made while the threat described in this Note may be growing.

It is also possible that some form of retaliatory threat could serve as deterrent against the use of chemical weapons. Different options, from economic sanctions to nuclear retaliation, have been considered as possible responses to chemical weapons use.

Factor	Scenario	
	NATO—WP	Regional
Course launch location	Satellites (~ 3 km)	Satellites (~ 3 km)
Precision search	Brilliant munitions searching dense terrain	Aircraft searching open terrain
Shoot and scoot time	Minutes	?
Time to kill (refire time)	Hours	?

Requirements eased with longer-range missiles

Fig. 22—Factors affecting counterfire feasibility

The effectiveness of deterrence depends on understanding the adversary's motivation for the attack, and on persuading him that the cost of the attack would be greater than the benefits that would accrue. The motivations of our European adversaries have been extensively studied with a view to developing a coherent deterrence theory. However, cultural commonality and understanding may be lacking with non-European adversaries, which means that conventional models need to be reassessed. The use of chemical weapons by the Iraqis in the Iran-Iraq war, and the mildness of the world's response to the admission that chemical weapons were used, indicates that deterrence may not be effective against these weapons in the Middle East. Indeed, it often appears that some countries launch attacks as a means of inviting retaliation to motivate domestic reaction.

There is a sharp contrast in how we think about ballistic missile threats in Europe and those with a Middle Eastern scenario. (See Fig. 23.) The differences are striking, and may require a complete overhaul in established thinking. Active defenses, passive defenses, arms control and deterrence, all of which may be considered reasonably successful in the European scenario, are unlikely to succeed in the Middle East for the reasons described in greater detail above. There is little interest on the part of nations in

Defense option	Europe	Middle East
Passive (chemical)	● Water available ● Moderate weather	● No water, heat ● Smaller quantities
ATBM	● <500 km TBMs	● Long-range TBMs ● ATBM portability
Counterfire	● Forests ● Air defenses	● Less mobile missiles ● Air superiority
Arms control	● Interested parties	● Disinterested parties
Deterrence	● Established thinking	?

Fig. 23—Attractiveness of current defense options

the region to participate in arms control, and restrictions on technology flow into the region have been ineffective. Since there is also little understanding of the most effective way to deal with the motivations for use of ballistic missiles and chemical weapons, new policies of deterrence will need to be developed. Counterforce, which has been found ineffective in the European scenario, may be more feasible in the different environment of the Middle East.

In this Note, we have presented an analysis of the current ballistic missile threat to U.S. facilities and operations worldwide. (See Fig. 24.) We have also looked at the way in which this threat is expected to evolve. It appears that the current arsenals of ballistic missiles are suitable for harassment, attacks on targets spread over wide areas, and terror attacks on cities. Armed with conventional unitary warheads, these missiles do not pose a direct military threat. However, both the missiles and chemical weapons are proliferating. If chemical warheads are put atop ballistic missiles, the threat to U.S. facilities and overseas operations could be serious. The future looks even less promising. As ranges of ballistic missiles increase, the ability of nations to enter conflicts outside their immediate geographic area grows—and this has the potential for destabilizing volatile regions. In addition, greater range increases missile survivability by permitting

- Current TBM forces could:
  - Threaten/harass U.S. facilities and operations
  - Not pose a major military threat
- Threat is becoming more severe due to increased
  - Number of "players"
  - Arsenal size
  - Missile range
- Advances in munitions and/or guidance technology would increase military severity of the threat
- Current arsenals could pose a militarily significant chemical threat

Fig. 24—Conclusions

nations to launch missiles from areas further away from hostilities. The solutions designed for combating these weapons in the European theater will not work in other regions of the world. This means that the U.S. Army and the Department of Defense must take a closer look at regional contingencies in order to devise methods for dealing with this growing threat to U.S. interests.

BIBLIOGRAPHY

No attributed author:

"Big Role for China: Arms Merchant," *Congressional Quarterly Weekly Report*, May 21, 1988, p. 1399.

"China/Missile Launching," International Media, June 10, 1988.

"Iran/New Long-Range Missiles," International Media, April 13, 1988.

"Land-Based Tactical Surface Weapons," *Jane's Weapon Systems 1988–89*.

"Libya Wants CSS-2," *Flight International*, May 14, 1988, p. 6.

"More Details of the Egyptian Sakr 80 Rocket System," *Jane's Defense Weekly*, March 12, 1988, pp. 462–463.

"Saudi Missile System Suffering the Slows," *Defense & Foreign Affairs Weekly*, November 28/December 4, 1988, p. 1.

"Saudis Secretly Deploying Missiles," *Washington Times*, September 20, 1988, p. 8.

"Soviet's Chemical War Chief Alerts West with Syria Visit," *Washington Times*, April 8, 1988.

"Syria/China Missile Deal," International Media, June 21, 1988.

"Syria/Iranian Missile Bases," International Media, April 18, 1988.

Almond, P., "Study Sees U.S. Tiring of NATO Ingratitude," *Washington Times*, October 18, 1988, p. 9.

Bickel, K. B., "'Poor Man's Bomb' Goes Global," *Los Angeles Times*, May 1, 1988, p. V-5.

Borowiec, A., "U.S. to Renew Negotiations on Military Bases in Greece," *Washington Times*, November 29, 1988, p. 7.

Branson, L., "Argentina in Missiles Deal," *London Sunday Times*, May 22, 1988, p. 19

Broder, J. M., "Rapid Mideast Missile Buildup Sparks Alarm," *Los Angeles Times*, July 31, 1988, p. 1.

Broening, S., "Israel Could Build Missiles to Hit Soviets, U.S. Thinks," *Baltimore Sun*, November 23, 1988, p. 1.

Calton, A., "Brazil's Growing Missile Industry," *Jane's Defense Weekly*, March 5, 1988, p. 401.

Carus, W. S., "Iran's Growing Missile Forces," *Jane's Defense Weekly*, July 23, 1988, pp. 126–131.

——, *Missiles in the Middle East: A New Threat to Stability*, Research Memorandum No. 6, The Washington Institute for Near East Policy, Washington, D.C., June 1988.

Cook, N., "Ironies of Saudis' IRBM Purchase," *Jane's Defense Weekly*, April 2, 1988, p. 627.

Copley, G., "The Road to Self-Sufficiency," *Defense & Foreign Affairs*, December 1987, pp. 24–33.

Cushman, J. H., Jr., "U.S. Suspects China Will Widen Arms Sales to Iran," *The New York Times*, March 13, 1988, p. 11.

Deen, T., "Egypt Set to Head Arab Arms Bid," *Jane's Defense Weekly*, April 9, 1988, pp. 681, 685.

DMS, Inc., *DMS Market Intelligence Reports: Missiles*, 1987.

Doerner, W. R., "A Deadly New Missile Game," *Time*, July 4, 1988, p. 38.

Dunn, M., "Arming for Peacetime: Egypt's Defense Industry Today," *Defense and Foreign Affairs*, October/November 1987, pp. 20–24.

Egbert, L. F., Jr., and J. O. Frankosky, *Technology List for Observing Possible Indigenous Development/Production of a Surface-to-Surface Missile System by a Less Developed Country (LDC)*, AC8WC122, Science Applications, Inc., Arlington, VA, 1979.

Fialka, J. J., "Chemical Weapons Spread in the Third World, Pose Challenge to West," *The Wall Street Journal*, September 15, 1988, p. 1.

——, "Western Industry Sells Third World Means to Produce Poison Gas," *The Wall Street Journal*, September 16, 1988, p. 1.

Fisher, D., "Israel Trying to Curb Missile Sales to Arabs," *Los Angeles Times*, July 6, 1988, p. 4.

Gavaghan, H., "India's Practical Path to Space," *New Scientist*, November 5, 1988, pp. 28–29.

Gordon, M., "Syria Is Studying New Missile Deal," *The New York Times*, June 22, 1988, p. 6.

——, "U.S. Fears Japan Aids Libya on Chemical Arms," *The New York Times*, September 18, 1988, p. 15.

Goshko, J. M., "Greek Plan to Close Air Base Surprises State Department," *Washington Post*, August 4, 1988, p. 24.

Horwitz, T., "Israel's Enemies Develop Alarming Poison-Gas Potential," *The Wall Street Journal*, September 15, 1988, p. 24.

Ibrahim, Y. M., "Saudis Warn Iran They May Use Chinese Missiles," *The New York Times*, April 29, 1988, p. 3.

Ingham, R., "NATO Divided on Greek Motive for Closing U.S. Base," *Washington Times*, August 5, 1988, p. 9.

Jenkins, L., "Greece Serves Notice It Will Close U.S. Bases," *Washington Post*, July 14, 1988, p. 22.

Jenne, M., "A Chemical Deterrence Force," *National Defense*, September 1988, p. 27.

Jumbert, N., "Iraq Uses Missile Blitz to Press for Cease-Fire," *Washington Times*, March 3, 1988, p. 8.

Kirkham, N., "Iraqui Gas Leaves 'a Modern Pompeii'," *Washington Times*, March 23, 1988, p. 1.

Kolcum, E. H., "Economic Pressures Shape South American Defense Issues," *Aviation Week & Space Technology*, March 14, 1988, pp. 81–82.

Lescaze, L., "Quest for Way to Block Biological Weapons Is Itself Called a Threat," *The Wall Street Journal*, September 19, 1988, p. 1.

Lopez, R., "Israel in Second Secret Test of Jericho IRBM," *Jane's Defense Weekly*, November 19, 1988, p. 1258.

Mann, J., "China-Syria Missile Deal Concluded," *Los Angeles Times*, July 14, 1988, p. 1.

Marcus, R., and D. Ottaway, "Egyptian Officer Tied to Smuggling Effort," *Washington Post*, June 25, 1988, p. 1.

McCartney, R. T., "Bonn to Work with U.S. Against Libyan Plant," *Washington Post*, January 27, 1989, p. 18.

Morrison, D. C., "Limiting Spread of Missile Know-How," *National Journal*, June 11, 1988, p. 1552.

Neilan, E., "Japan Likely to Pay Part of U.S. 'Rent'," *Washington Times*, August 4, 1988, p. 8.

Nordland, R., "The Bombs in the Basement," *Newsweek*, July 11, 1988, pp. 42–45.

Ottaway, D. B., "In Mideast, Warfare Takes a New Nature," *Washington Post*, April 5, 1988, p. 1.

——, "Israelis Aided China on Missiles," *Washington Post*, May 23, 1988, p. 1.

——, "U.S. Asks Soviets, Chinese, to Cease Ballistic Missile Sales in Middle East," *Washington Post*, May 26, 1988, p. 16.

——, "U.S. Notes 'Strong Indications' China Is Sending More Missiles to Tehran," *Washington Post*, December 25, 1987, p. a37.

Pear, R., "The Soviets Have Ample Competition in the Mediterranean," *The New York Times*, September 4, 1988, p. E-2.

Pejman, P., "Egyptians Update Iraqui Missiles," *Chicago Tribune*, May 5, 1988, p. 28.

Peterson, J. E., "Japanese Firm Tied to Libyan Nerve Gas Plant," *Detroit News*, September 22, 1988, p. 1.

Quayle, D., *Ballistic Missile Update 1988*, United States Senate, June 24, 1988.

Rempel, W. C., and R. Wright, "Vigilance, Luck Expose Libya Plant," *Los Angeles Times*, January 22, 1989, p. 1.

Ropelewski, R. R., "Israel Wary of High Technology Weapons Buildup In Middle East," *Aviation Week & Space Technology*, July 25, 1988, pp. 44–45.

Sale, R., "Saudis Said to Aim Missiles at Iran," *Philadelphia Inquirer*, May 17, 1988, p. 8.

Stanglin, D., et al., "The Missile Trade in Launch Mode," *U.S. News and World Report*, July 25, 1988, p. 32.

Tuohy, W., "Iraqis' Use of Poison Gas Stirs Fears of Proliferation," *Los Angeles Times*, August 28, 1988, p. 1.

Tyler, P., "Iraq Targets Bigger Missile on Tehran," *Washington Post*, March 28, 1988, p. 17.

——, "U.S. Drawn Into Gulf Dispute," *Washington Post*, October 6, 1988, p. 44.

U.S. and World Military and Government Installation Directory Service, *U.S. and World Military and Government Installation Directory*, 1986.

U.S. Department of State, Missile Technology Control Regime: Public Statement, Fact Sheet To Accompany Public Announcement, Equipment and Technology Annex, April 16, 1987.

Watson, R., et al., "Another Arms Race," *Newsweek*, April 11, 1988, pp. 40–42.

——, "Why China Sells Arms," *Newsweek*, July 4, 1988, pp. 23–24.

Wayne, E. A., "Tracking Chemical Weapons in the Gulf War," *Christian Science Monitor*, April 13, 1988, p. 32.

Weintraub, R. M., "India Test Mid-Range 'Agni' Missile," *Washington Post*, May 23, 1989, p. 1.

White, D., "Indian Missile Test Raises Fears of Arms Proliferation," *London Sunday Times*, May 25, 1989, p. 6.

Whittaker, G., "Crete's Role in NATO Missile Crew Training," *Jane's Defense Weekly*, April 23, 1988, pp. 794–795.

Wilson, G. C., and D. Ottaway, "Saudi-Israeli Tensions Worry U.S.," *Washington Post*, March 25, 1988, p. 1.

Wright, R., "Chemical Arms: Old and Deadly Scourge Returns," *Los Angeles Times*, October 9, 1988, p. 1.