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1a Report	"Study of Ballistic Missile Proliferation" S 43 p. ~~sanitized 2-28-05 NLJ 02-17~~ more info released 2-14-06 NLJ 02-17 appeal	1/1/65	A
1b Annex	Annex to 1a Report S 10 p. ~~sanitized 2-28-05 NLJ 02-17~~ more info released 2-14-06 NLJ 02-17 appeal	n.d.	A
~~2 Memo~~	~~Scoville to Komer~~ ~~C 1 p.~~ open 2-28-05 NLJ 02-17	~~1/18/65~~	~~A~~
~~2a Report~~	~~"The Proliferation of Rocket Technology"~~ ~~PCI 27 p.~~ open 2-28-05 NLJ 02-17	~~1/1/65~~	~~A~~
~~3b Memo~~	~~Ball to the President~~ ~~S 2 p.~~ open 6-23-04 NLJ 04-8	12/18/64	~~A~~
~~3c Draft~~	~~Draft letter to Eshkol~~ ~~S 3 p.~~ open 6-23-04 NLJ 04-8	~~n.d.~~	~~A~~
3d Paper	"Danger Signs of..." S 2 p. ~~exempt 2-28-05 NLJ 02-17~~ exemption upheld 2-14-06 NLJ 02-17 appeal	n.d.	A

FILE LOCATION

NSF: Files of Robert W. Komer
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UNITED STATES ARMS CONTROL AND DISARMAMENT AGENCY
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Number 17 of 76 copies, Series A

November 9, 1965

Nuclear weapons

MEMORANDUM

TO: White House - Mr. Robert Komer

FROM: ACDA/ST - Herbert Scoville, Jr.

SUBJECT: Staff Study on Ballistic Missile Proliferation (U)

The further spread of nuclear weapons is recognized as a threat to U.S. and world security. However, the dissemination of systems capable of delivering nuclear weapons interacts with nuclear proliferation and is also a serious issue. Both of these related problems have been of concern to ACDA in our continuing efforts to understand and deal with the overall question of proliferation.

Attached for your information is a staff study which focuses on perhaps the most important class of nuclear delivery systems--ballistic missiles. The purpose of the study is to identify and define the problem of ballistic missile proliferation, and provide an initial analysis of the subject from an arms control viewpoint. Any personal comments you may have would be appreciated.

Attachment:

Staff study

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This document consists of 53 pages.
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AN INITIAL STUDY OF BALLISTIC MISSILE PROLIFERATION (U)

by

Jerome H. Kahan

Science and Technology Bureau

UNITED STATES ARMS CONTROL AND DISARMAMENT AGENCY

November 1, 1965

ST 3920

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I. BACKGROUND

The problem of the proliferation of nuclear weapons has been clearly recognized as a threat to the security of the U.S. and as a serious danger to world peace and security. However, the question of nations acquiring the means of delivering nuclear weapons is also serious, and, of the various means of delivery, ballistic missiles are of prime importance.

Once a nation has developed nuclear weapons and even if aircraft are available, the military and political significance of its nuclear capability will be considerably increased if associated with a missile delivery system. Conversely, if a nation can acquire a missile delivery system, the probability that it would decide to pursue an indigenous nuclear weapons program--or even attempt to purchase nuclear weapons--may well increase. If the further spread of nuclear weapons could be controlled, it could be argued that missile proliferation would be relatively unimportant; however, since this result is not certain, retarding the spread of nuclear forces by considering ballistic missiles is a vital part of the overall non-proliferation effort.

The bulk of the effort expended by the U.S. Government in the arms control and security area has been vis-a-vis the Soviet Union; lately the Nth country proliferation problem--nuclear weapons and delivery systems--has received increased attention. In particular, the acquisition of ballistic missiles by Nth countries, when related to the spread of nuclear weapons, has many dangerous ramifications for world stability, such as increasing the chance of a nuclear war occurring (through accident or miscalculation) and making it less likely that arms control agreements can be reached. In addition, the question of missile proliferation interacts with future U.S. (and Soviet) decisions on ABM deployment.

Although ballistic missile proliferation has undesirable aspects, the development of rockets for peaceful space purposes constitutes a growing and legitimate worldwide activity, and more and more nations are finding space a significant field for national and cooperative efforts. Basic space rockets and technology, however, can provide potential missile capabilities to nations. This problem of accepting, and even furthering, the spread of peaceful technology which also leads to increased military capabilities has been faced with regard to nuclear energy but has not been explored to nearly the same degree from the viewpoint of missiles and rockets. The question of safeguarding transfers of rockets and related technology has, for instance, not been systematically examined.

To help cope with the problems raised by missile proliferation, arms control measures and modifications in unilateral policies which affect Nth country ballistic missiles and space rockets will probably be required. Furthermore, presently developed measures affecting nuclear delivery vehicles, such as the SDV "freeze", will necessitate continuous re-evaluation with respect to including additional countries on the basis of their missile and rocket capabilities.

II. PURPOSE AND SCOPE

The purpose of this study is to identify and define the problem of ballistic missile proliferation, and provide an initial analysis of the problem from an arms control viewpoint.

In order to limit the scope of the initial effort, this study focuses on surface-to-surface ballistic missiles which are capable of delivering nuclear weapons over distances that are strategically significant for Nth countries. The proliferation of large space rocket systems which increase a nation's ability to produce nuclear-capable ballistic missiles is also of interest. All countries other than the Soviet Union and the U.S. are defined as Nth countries; the U.S. and the Soviet Union are considered from the viewpoint of their technical, military, and political influences.

Specifically, the central concern of this study is with the kinds of surface-to-surface ballistic missile systems (vehicle and ground-support equipment) which are capable of carrying payloads of 1,000 lbs. <u>or more</u> distances of <u>at least</u> 200 miles. Distances down to 200 miles encompass most "strategic" Nth country situations, and the constraint on payload weight represents a reasonable lower limit for early generation Nth country nuclear weapons.

Although beyond the scope of this study, it is nevertheless recognized that the problems associated with the spread of advanced aircraft capable of carrying nuclear bombs, the possible use of cruise (i.e., non-ballistic) missiles by Nth countries, and the role of small ballistic missiles with non-nuclear payloads in Nth country situations are all issues which deserve serious attention.

III. SUMMARY AND CONCLUSIONS

The following is a summary of the most pertinent aspects and principal conclusions of the study; the first four paragraphs relate to the Nth country missile problem, while the last three deal with U.S. policies and the role of arms control:

1. Nth countries desire ballistic missiles for military and political reasons, and tend to be particularly concerned with developing "credible" nuclear strategic missile forces to further national goals. The desire for nuclear missiles is particularly heightened by the growing tendency to classify nuclear powers into first-class and second-class powers depending upon whether or not they have missile delivery systems. Many nations are presently producing small rockets, but very few are developing satellite-launch vehicles or nuclear-capable missiles. The proliferation of nuclear-capable ballistic missiles, in the context of possible nuclear weapons proliferation, has dangerous implications for U.S. and world security.

2. Although basic rocket technology has already spread, even relatively advanced nations encounter difficult, costly, and time-consuming problems when attempting to develop, test, produce, and deploy ballistic missile systems in significant quantities. Moreover, nations will have difficulty developing nuclear payloads for ballistic missiles, even if they have a basic nuclear weapons capability. A typical "partially industrialized" nation could produce a modest quality IRBM in 8 to 10 years and develop compatible nuclear payloads in a comparable period of time. Thus, because missile production is difficult and requires extensive effort, proliferation through this mode is not necessarily inevitable, and the prevention or control of missile proliferation appears feasible.

3. If a nation pursues an advanced space rocket program, it will be in a better position to develop nuclear-capable ballistic missiles and could retain this option. In general, conversion of large space rockets could provide a nation with a missile system more easily than direct production, but a fairly advanced scientific and industrial base is needed to

perform the conversion; conversion of small rockets to nuclear-capable missiles involves virtually complete production. Conversion programs can proceed quite far within the scope of peaceful space activities, either legitimately or by design, but, at some point, military characteristics such as flight testing, construction of many launch facilities, or some other indicator or combination of indicators would probably reveal a missile program.

4. Nth countries could acquire missiles (or easily convertible space rockets) through direct purchase, assuming there is a willing seller. Only a few nations are presently in a position to transfer nuclear-capable ballistic missiles or satellite-launch vehicles. These transfers are generally made on the basis of complex military, political, and economic factors in the same way as sales of other advanced weapons. Due to limited supplier capabilities and some recognition of proliferation problems, the present missile-transfer situation is not critical. Furthermore, nations do not acquire significant incremental capabilities for indigenous missile production through the ownership and operation of missile or space rocket systems. However, it is possible that regional or perhaps worldwide "missile-seller" races could occur as more nations develop missile production industries and as the demand for missiles and rockets increase.

5. The commercial export of missiles and rocket-related items from the U.S. requires government licensing, and U.S. export laws and procedures are in general adequate. Nevertheless, the U.S. is the world's largest supplier of these items through the cumulative effect of commercial exports of large quantities of dual-purpose or individually innocuous missile-related hardware and data, and through connections between U.S. and foreign firms. DOD military sales do not provide other nations with missile production capabilities, and although no explicit controls over the use of end-items exists, unauthorized use does not seem to be a present danger. Future cooperative ballistic missile production arrangements, if established, could present problems by proliferating indigenous production capabilities. NASA's international cooperative rocket programs do not incorporate the transfer of rocket production technology, and, because of this and other factors,

no missile proliferation problems are involved. However, controlling missile proliferation through "safeguarded" multilateral rocket cooperation might offer possible benefits.

6. NSAM 294 provides an excellent basis for U.S. missile proliferation policies, but it would be useful to redraft the NSAM to express formally its present application to all nations (not only France). The efficacy of U.S. missile non-proliferation policies depends primarily upon the priority assigned to the policies themselves. However, among the technical problems which should be investigated in order to help formulate and adequately implement these policies are: the systematic identification of "critical aspects" of Nth country missile programs; the question of "reverse engineering" for rockets (i.e., learning to produce purchased items by analyzing them); and the feasibility of a "two-key" system for ballistic missiles. There is, moreover, room for improvement on such legal matters as controlling work on foreign weapons programs by personnel under U.S. jurisdiction. U.S. unilateral information regarding Nth country missile and rocket programs is vitally important in support of unilateral policies and possible arms control measures.

7. Obtaining formal and informal multilateral arms control arrangements affecting missiles and rockets could help ensure the success of U.S. missile non-proliferation efforts. Examples of arms control measures which might be explored are: regional missile supplier/receiver arrangements; a missile non-dissemination agreement; and attempts to increase the priority and effectiveness of the missile export policies of other nations. In addition, the feasibility of "safeguarding" the transfers of rockets and technology in support of unilateral policies and with possible application to regional or international "space agencies" should be studied. The concept of an international satellite launch facility should also be examined as a means of complementing and reinforcing non-proliferation efforts.

IV. DISCUSSION

A. FACTORS AFFECTING MISSILE PROLIFERATION

This section highlights the political, military, and scientific factors related to missile proliferation, and examines the reasons *why* missiles proliferate. Section B describes the various modes of missile proliferation--that is, *how* missiles proliferate--and amplifies the more technical aspects of this section. The present Nth country missile situation is summarized in the Annex; readers desiring such background information might refer to the Annex at this point.

1. Importance of Ballistic Missiles

The importance of nuclear-armed ballistic missiles in a great power context has been underscored by the U.S. and the Soviet Union through the development and justification of their strategic missile forces. However, this view has been transferred to Nth countries as well. The U.S. has indicated, for instance, that the Communist Chinese nuclear threat will not become "significant" until China acquires a ballistic missile delivery capability. And, by denigrating the *Force de Frappe*, the U.S. and the Soviet Union have assigned additional prestige to French missile efforts.

On strategic grounds, nations recognize the value of nuclear-capable ballistic missiles. While many Nth countries already own, or can obtain, aircraft capable of delivering nuclear weapons, there are relatively good means of defense against aircraft available, while effective ballistic missile defense in an Nth country context is virtually impossible for most nations to achieve without major external assistance. Even a few nuclear-armed missiles in the hands of an Nth country increase the political and military significance of its nuclear capabilities regionally and, to a lesser extent, vis-a-vis the major powers.

Thus, the extent to which nuclear weapons have been viewed as "the great equalizer" among large and small powers appears to be changing. There is a growing realization that it is the nuclear-armed missile which is the "ultimate weapon," and that there are two classes of existing, or potential, nuclear powers--those with ballistic missiles and those without them. This makes it more likely that ballistic missiles will proliferate in conjunction with nuclear weapons, and suggests that there are important interactions between the two problems.

Ballistic missiles with non-nuclear warheads have some political and psychological value but limited military utility in most Nth country contexts. Nevertheless, as suggested by the UAR situation, nations having no nuclear capability might desire missiles for these reasons or on the assumption that nuclear warheads might eventually be "acquired." Also, efforts by a country to obtain nuclear delivery vehicles, particularly ballistic missiles, could cause increased suspicions of its intent to acquire nuclear weapons, which could in turn stimulate nuclear and missile activities. Additionally, through sheer momentum, arms races in the area of advanced conventional weapons (e.g., aircraft or non-nuclear missiles) might tend to carry over into the nuclear delivery vehicle (and nuclear weapon) field, and could reinforce missile proliferation pressures.

Due to economic reasons or because of military or political factors (such as alliance membership or possible nuclear guarantees from the major powers), certain Nth countries might decide not to undertake strategic nuclear programs in the future. However, some nations might still wish eventually to develop ballistic missiles for political and prestige reasons, although some goals could be pursued through peaceful space rocket programs. On the other hand, even Nth countries with nuclear capabilities might find it more in their interest to rely on aircraft delivery only or to develop "bypass" weapons (e.g., nuclear-armed cruise missiles or delivery by ships) rather than to undertake ballistic missile programs.

Finally, possible ABM deployment against Nth country threats by the U.S. and/or the U.S.S.R. interacts with the problem of missile proliferation. ABM deployment could dissuade nations from acquiring ballistic missiles by decreasing the utility of missiles vis-a-vis the U.S. and the U.S.S.R. and increasing the credibility of assurances by the major powers. On the other hand, ABM deployment could stimulate the desire for missiles among Nth countries by starting a new round in the strategic arms race, and ABM systems themselves might begin proliferating.

2. Relation to Nuclear Weapons

From a technological viewpoint, a combined nuclear warhead/missile delivery capability requires considerable missile technology (i.e., reasonably accurate and relatively powerful missiles) plus an advanced nuclear weapons capability (i.e., small and light nuclear weapons), each of which is difficult and time-consuming to achieve. A nation might not consider starting a large missile development program unless it undertook a parallel nuclear weapons program which could "converge" at the appropriate point in time with the missile program.

If a nation is far from a nuclear weapons capability it might choose not to undertake a missile program since ballistic missiles with conventional warheads are of marginal utility and producing a ballistic missile force is a time-consuming, costly, and uncertain undertaking. Additionally, since the nuclear weapons initially developed by Nth countries would be large and heavy, aircraft delivery might be the only feasible mode until and unless a small, lightweight nuclear payload is acquired. It should be noted that constraints in nuclear weapons testing, such as the partial test ban, would increase the difficulty and time involved in the development of nuclear weapons more conducive for use with missiles.

To the extent that a nation would find it difficult to acquire a missile capability, it might well be dissuaded from undertaking a nuclear program which would result in a "second-best" (i.e., aircraft only) deterrent force. On the other hand, since acquiring nuclear-capable ballistic missiles increases the significance of nuclear weapons, a potential (or existing) missile capability might stimulate a nation's desire for obtaining nuclear weapons.

With increasing space rocket developments, certain nations may be in a position to acquire a missile capability (through conversion) more easily and rapidly than they could develop nuclear warheads. The Japanese are approaching this situation, for example. On the other hand, many nations which could produce nuclear weapons relatively easily might not have the industrial and scientific capabilities needed to develop a large space rocket or ballistic missile system in a reasonable period of time--or at all. India, for instance, is, and will probably remain, closer to a nuclear weapons than to a missile capability.

3. <u>Nth Country Missile Requirements</u>

Powerful nations, such as France (which is well along in an IRBM program) and China (which is developing and testing ballistic missiles), tend to acquire fairly sophisticated missiles in order to gain maximum military credibility, political leverage, and world prestige. This tendency would probably be reflected in most Nth country situations. Additionally, from a strictly military point of view, it would be in the interest of an Nth country to deploy a reasonably invulnerable missile force (through concealment, hardening, or even sea basing) in order to decrease the chance that it might be pre-emptively attacked by an Nth country adversary--which might be able to do this without using missiles--or by a major power.

Thus, even if a nation could produce or acquire a "primitive" missile (i.e., low reliability, accuracy, etc.), it might not deploy such a system. Rather, a nation might continue missile development efforts and/or pursue a large-scale space rocket program in order to achieve a "standby" capability for sophisticated missile production.

Since unguided missiles at ranges of 200 miles or more are inaccurate (i.e., CEPs of 10-20 miles), Nth countries will have to incorporate some type of guidance in their missiles. Simple guidance systems, such as autopilots, can improve accuracy somewhat, but more sophisticated radio and/or inertial guidance systems would most likely be utilized.

It should be recognized, however, that many Nth countries do not require high quality missile performance. Reliabilities of even 50% and accuracies of a few miles would suffice for countercity deterrent roles. Applying U.S. and/or Soviet weapons standards or strategic criteria to other nations could result in misinterpretations of Nth country missile threats, particularly in regional contexts.

4. Scientific and Technological Aspects

Following the lead of the great powers, and based upon genuine scientific and prestige considerations, almost every nation of the world is involved in some sort of space research. Although basic space rocket and missile technology are similar, only nations with advanced space rocket capabilities are able easily to develop ballistic missiles by utilizing their space capabilities and "converting" space rocket systems to ballistic missile systems.

While many nations are presently producing sounding rockets, small battlefield rockets, SAMs, etc., few are undertaking large space rocket programs. Most nations are engaged only in support and experimental space activities, not in rocket production. However, during the next five to ten years, more nations will undertake advanced, more extensive space programs for a variety of reasons.

Nations could and might pursue space rocket programs on purely peaceful grounds, while at the same time retain the option to utilize their technological base and rockets for military purposes should the need ever arise. Japan is virtually in this position now. While this situation would appear to be optimal from the point of view of the Nth country, it leads to problems with respect to the larger powers, who recognize and wish to assist other nations in achieving a peaceful space capability but also realize that this may result in an increased military rocket capability.

Nations might undertake more extensive space rocket programs to obtain industrial and scientific side-benefits from such activities. Furthermore, economic factors may contribute to greater rocket production by industrialized Nth countries, as worldwide commercial markets open up and exports increase.

B. MODES OF MISSILE PROLIFERATION

There are three principal ways by which nations acquire ballistic missiles--production, conversion, and purchase. Although these proliferation "modes" are not completely unrelated, each has its own characteristics and is discussed separately.

1. Indigenous Missile Production

a. Production Difficulties

Basic rocket technology has already proliferated, and in this sense one could argue that the "missile Genie" is out of the bottle, and nothing can be done. Missile and rocket principles are well known; design and engineering information is available in open sources; and materials, components, and production equipment are relatively widely available. In addition, many nations already have some sort of indigenous rocket production capability, generally involving small research rockets or battlefield missiles, and a few nations are already developing powerful space rockets or ballistic missiles. Theoretically, then, given enough time, resources, and money, almost any nation could develop a short-to-medium range ballistic missile system (capable of carrying a nuclear warhead) or powerful space boosters which can be easily converted. Dr. A. J. Hibbs has pointed out in his paper, "The Proliferation of Rocket Technology," that any partially industrialized nation could, in about eight to ten years, develop a modest quality missile capable of carrying a 1,000 lb. (i.e., nuclear) warhead a distance of 1,500 miles.

However, the fact that technology has proliferated does not mean that it is an easy or certain undertaking for a nation to develop a ballistic missile or large space rocket system, any more than the widespread knowledge of basic nuclear weapons technology and the existence of many nuclear reactors implies that producing nuclear weapons is easy. The costs and resources involved in developing, testing, and deploying even a small, modest quality ballistic missile force are great, and a major national commitment is required. The view that an indigenous ballistic missile program is in fact a difficult undertaking is supported by the history of the early U.S. missile and space efforts, the present technical problems being encountered by the ELDO and French national programs, the economic and other factors besetting UAR missile production, and the U.K.'s abortive attempt at deploying an IRBM force. Additional aspects which compound the situation are the uncertainties as to the estimated time and cost of a proposed system, and the possibility that the system will not be as good as anticipated or, even if it is, that it will be militarily obsolete or politically impotent.

The relative difficulty of producing ballistic missiles clearly depends upon the particular country involved--its scientific, military, and industrial base, and the numbers and kinds of missiles desired. Nations already producing small sounding rockets, battlefield or defensive missiles, or advanced aircraft would be better able to undertake a ballistic missile prgram than nations which do not have these kinds of capabilities. However, as will be discussed subsequently, only an advanced space rocket production capability will significantly reduce the time and effort associated with an indigenous ballistic missile program. External help from major powers in providing needed components and equipment and in establishing and operating production and test facilities could, on the other hand, substantially reduce an Nth country's burden, and acquiring the services of rocket production experts can be extremely helpful.

b. Elements of Missile Production

In order to indicate more specifically the difficulties associated with missile production and the nature and scope of the effort required, the following discussion highlights the more important aspects of a ballistic missile production effort which might be undertaken by a typical "relatively industrialized" Nth country having no ongoing large-scale space rocket development program.

For both solid and liquid-fueled rockets a broad industrial base for design, development, production, testing, and deployment is required--even broader than that needed for producing nuclear weapons. This base includes advanced metal-working facilities, chemical industries, propulsion capabilities, and sophisticated electronics and test equipment. Initially hundreds and eventually possibly thousands of skilled scientific, engineering, management, and operating personnel are needed, and large-scale training programs might be required.

The bulk of the time and effort (but not necessarily cost) associated with a ballistic missile program is spent on development, more specifically on the research, development, testing, and evaluation sequence. Once a missile system has been developed and a number of prototypes have been produced and successfully tested, so-called "series production" can begin. Developing a guidance and control system would present the single most difficult problem to almost any nation indigenously producing its own advanced space or ballistic missile system, even though accuracy requirements may not be as stringent as those of the U.S.* In the initial phases of series production,

*France and Japan, two nations with advanced rocket capabilities, appear to be finding guidance the "pacing item" in their programs, despite the fact that many modest quality inertial and radio guidance components are available on the world market.

some design changes or modifications may be incorporated, but eventually a relatively steady production rate can be achieved (e.g., two, three, or perhaps ten missiles per month). Deployment of these missiles depends, of course, upon the availability of launch sites.

In addition to the need for testing and quality assurance associated with missile development and production, flight testing must be undertaken to verify system performance, detect design errors, gather empirical data on such critical factors as accuracy and reliability, and for purposes of crew training. For missiles of ranges greater than that of about 1,000 miles, flight testing is particularly critical in terms of understanding and solving re-entry problems. Flight test ranges would have to be established, and this might require small nations to look elsewhere for ranges of adequate size. Range instrumentation and support facilities would be required, but the exact equipment used would vary depending upon flight test objectives and number of flight tests required.*

The time needed to develop, test, produce, and deploy a ballistic missile or space rocket system depends upon many factors including the existing industrial and rocket base of the particular nation involved, the amount of effort and resources applied, and the type and number of missiles programmed.** In general, even with a crash program, a country inexperienced in rocket technology could not deploy 20 or 30

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*The number of flight tests needed essentially depends upon the degree of reliability and quality control desired. On the average, for short-to-medium range ballistic missiles, between 15 and 25 flight tests would be necessary. Initial tests could be carried out at reduced range, but later tests would most likely be at full range.

**The time referred to covers the entire development-production-deployment sequence; once series production begins the time per missile is relatively short (on the order of a few months), and, if hardened sites are involved, the launcher associated with each missile is the longest lead-time item.

modest quality missiles capable of carrying nuclear-weight payloads over 200-1,000 mile distances in less than four to five years. The eight-year period represented by the German V-2 schedule is probably more realistic, while a ten-year allowance would be conservative. The Japanese space rocket program, for example, is in its tenth year and Japan has not yet launched its first satellite.

The cost associated with a space rocket or ballistic missile system can be considered to consist of the development cost plus the additional cost (per item) for each missile produced during series production. Development costs encompass production facilities and related equipment, missile hardware, flight test facilities, and ground support equipment (which generally accounts for more than half the total cost). Although quite substantial, the absolute cost or percent of the GNP of a missile or space rocket system, however, is not necessarily an accurate measure of its impact on the economy of an Nth country. Since these programs utilize industrial capabilities and scientific talent which might be applied elsewhere, there could be a greater adverse economic impact than might be expected. On the other hand, because of the breadth and depth of engineering and scientific capabilities associated with the development of large rocket systems, nations can enhance their technological base and gain industrial side-benefits.

Instead of presenting general cost estimates, the following examples indicate the range of figures involved for a variety of Nth country situations:

(1) The cost of developing, producing, and operating the French land-based IRBM program over the ten year period from 1960 to 1970 is estimated to total between \$1.25 and \$1.75 billion. The bulk of this cost will be for series production of between 50 and 200 missiles with associated hardened launch sites. This cost represents an average of about 1% of the French GNP.

(2) The Japanese solid-rocket space program is an example of a 10 year development effort to achieve a sattelite

launch rocket. The total 10 year cost to date is estimated at $50 million; a possible $120 million additional is estimated for the next five years (for production and support of satellite rockets.) If the Japanese were to use their space rocket capabilities and develop ballistic missiles, the development effort associated with "conversion" would cost about $500 million ($200 to $300 million could be part of the advanced space program.) It is estimated that a force of 200 IRBMs and 100 soft sites could be produced and deployed by Japan at a cost of anywhere between $1 and $2 billion (by 1969); this would be below 1% GNP.

(3) As an example of a nation with a modest industrial base and no ongoing rocket program of any significance, consider India. It is estimated that the development of a satellite launch rocket (minus the satellite) would cost India about $55 million over a period of eight years.

(4) [redacted] 3.3 (b)(1)

c. Interaction with Nuclear Weapons

Since the principal significance of ballistic missiles from the viewpoint of this study is related to their use with nuclear payloads, it is important to consider the time Nth countries would require to develop missile-compatible nuclear warheads. Although again generalizations are difficult, and each nation is different, "partially industrialized" nations which could, as discussed, develop a nuclear-capable missile in about eight years would need about this same time period to develop a nuclear weapon weighing about 1,000 lbs. which could be carried by the missile. This assumes that a primitive nuclear "device" could be developed in about four years. Clearly, for nations with advanced nuclear capabilities this time would be reduced.

More specifically, based on the U.S. nuclear program and the [redacted] experiences, it is fair to state that the first device which a nation tests weighs about 5,000 to 10,000 lbs. (including the case or re-entry body) and that about four more years are needed to reduce this weight by a factor of 10 to 1,000 lbs., assuming fission bombs are involved. Further improvements in yield-to-weight ratios are difficult to achieve, and have been achieved by the U.S. and the Soviet Union but with great effort and sophistication. Development of thermonuclear weapons can, of course, significantly reduce yield-to-weight ratios, but a 1,000 lb. fission device would most likely precede a fusion device of comparable weight (but far greater yield). 3.3 (b)(1)

2. Conversion of Space Rockets

a. Basis for Conversion

The scope of space research and exploration programs has been expanding in depth and in the number of nations involved. Hundreds of sounding rockets for meteorological research are launched each year, and many bilateral and multilateral cooperative programs are underway around the world in the space field. The United States, through NASA and its cooperative programs, is working with nations in many peaceful space activities. The U.N. and organizations such as COSPAR are also active in the space area. These programs involve data exchange, project coordination, or scientific experimentation; they do not provide Nth countries with rocket production capabilities.

Many nations already have limited space rocket programs, and a few have relatively advanced space programs (e.g., Japan). European nations in particular, through national efforts and cooperative programs such as ELDO and ESRO, have a growing interest in space.

The basic industrial capabilities and skills for the production of space rockets are generally applicable to the production of missiles. As a nation develops more sophisticated and larger sounding rockets, perhaps attaining a satellite launch capability, it builds up a broader indigenous base of facilities and expertise from which to undertake a ballistic missile program. Nations can build larger and larger rocket capabilities by progressing in steps from small and modest space rockets to larger and larger rockets as manifested by the Japanese solid-rocket program.

b. Conversion Effort

Most space rockets--particularly the widespread class of small sounding rockets and small military rockets, SAMs, etc.--would not satisfy the range/payload requirements for the ballistic missiles considered "strategic" and of interest in this study. If an Nth country has the capabilities to produce small rockets, obtaining ballistic missiles or powerful space rockets (which are relatively easily converted to ballistic missiles) would require a substantial effort. Extensive developmental work, testing, and virtually new production facilities would be required. More powerful rockets could be developed through a number of techniques, including staging and/or clustering smaller boosters, increasing the energies of rocket fuels associated with smaller rockets, or, of course, directly developing larger and more powerful boosters. Appropriate guidance systems would, in general, also have to be developed (or acquired) and tested.

The conversion effort needed to develop ballistic missiles or powerful space rockets starting from small rockets and associated capabilities essentially amounts to production, and would involve approximately the same time, cost, and resource factors discussed above. Moreover, if a nation with no indigenous rocket capability and an unsophisticated industrial base acquires small space rockets, conversion would be extremely difficult, if not impossible, to achieve.

Conversion of certain powerful space rockets to ballistic missiles, can, on the other hand, be more easily accomplished. All satellite launch rockets and some high-energy sounding rockets have innate capabilities in terms of thrust and, for some rockets, guidance that allow them to be utilized, with minor modifications, as short-to-medium range (e.g., 200-1,000 miles) missiles with nuclear payload capabilities. These modifications may include structural changes, engine recalibration, guidance and control adjustments, and elimination of excess telemetry components.* In addition, missile launch facilities would have to be established, and series production undertaken on an increased scale to mount the desired force.

As an example, the Japanese space program provides a base for the development of a missile effort. Assuming that a MU-type vehicle for satellite launching is successfully developed in 1965 and allowing an additional two to three years for a missile flight test program and the incorporation of changes in the guidance and ground support system, it is estimated that a nuclear-capable (2,000 lb. payload) IRBM based on this vehicle could reach initial operating status in 1968 or early '69. Cost estimates for this conversion were given in the previous discussion of missile production.

It should be recognized, however, that a conversion effort is relatively easy for nations which have actually produced the space vehicle or have equivalent advanced industrial capabilities. If a nation with a primitive rocket program and unsophisticated industries acquires a powerful space rocket, conversion would not be easy or certain, and maintaining a missile force would present problems. (These and other facets of rocket purchases are discussed below.)

c. Space Rocket Versus Missile Characteristics

Although powerful space rockets can, in general, be relatively easily converted to ballistic missiles, this does not mean that space rocket and ballistic missile systems are identical. On the contrary, there are a number of important differences in terms of both basic characteristics and performance requirements which complicate and provide indications of a conversion effort:

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*As in the case of indigenous production, development of an adequate guidance and control system, if not available or able to be purchased, would probably be the most critical factor in conversion.

(1) Military systems utilize many launching sites; this differs from space systems where even the major powers have relatively few launch facilities. Additionally, many nations would not be satisfied with constructing soft pads, but would desire to attain some degree of missile survivability through hardening or mobility (aside from reliance on numbers).

(2) The shape and nature of military re-entry vehicles are different from space payloads and, in general, there are no space applications for missile R/V's and no ballistic missile applications for space payload packages. Most scientific space payloads do not return to earth and none generally returns at steep re-entry angles (i.e., high speeds). Ballistic missiles of ranges greater than about 1,000 miles require that the R/V's have proper heat shielding because of high speed re-entry; missiles of ranges below 1,000 miles do not encounter significant re-entry heating problems.

(3) Most satellite launch vehicles utilize radio guidance because of its flexibility; however, inertial guidance may be preferable in some situations. Although both radio and inertial guidance systems are used in ballistic missiles, inertial systems are more desirable in a ballistic missile program. Unguided space rockets have almost no military utility in Nth country situations.

(4) Although in the initial phases of both space and military programs the flight test conducted follow similar patterns, military systems require additional and somewhat different flight testing for re-entry body development, accuracy and reliability refinements, and crew training.

(5) Both liquid and solid-fueled rockets can be used in advanced space or ballistic missile systems, but liquids tend to be preferred in space work since they are presently capable of achieving higher specific impulse and provide greater flexibility. In a military role, where quick-reaction and survivability are more important, solids or storable liquids rather than non-storable (cryogenic) rockets would probably be utilized.

The characteristic differences between space and military systems discussed above should be considered in any evaluation of the feasibility of conversion and the military capabilities of space rockets. These differences become even more important when considering the problem of a nation attempting to develop a missile system under the guise of a space program since, at some point, certain military indicators such as re-entry testing, construction of large numbers of launch sites, and an increased production rate could arise. On the other hand, by the time certain indicators are observed, the effort could be fairly well advanced and appropriate responses might be less possible.

3. Purchasing Missiles

a. Missile Suppliers

Although many kinds of missile-related components and equipment and small sounding rockets are commercially available from the U.S., France, Japan, and other countries, larger rockets and ballistic missiles of interest in this study are not widely available.* This is due, in part, to the fact that most nations have not yet developed their own indigenous capability, but appears also to reflect some recognition by the suppliers of the potential dangers associated with indiscriminate missile transfers. At the present time, the possibility of misuse is low since supplier nations generally are aware of the location and use to which the missiles are put.

Indications are that from the viewpoint of Nth countries, France and Japan appear to be emerging as potential missile and rocket suppliers. Israel has arranged to purchase short-range nuclear-capable ballistic missiles being produced by a French firm. Whatever one might think about French policy, this sale might not necessarily indicate that the French intend

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*Missiles such as SAMs are fairly widespread, but are usually part of military sales or assistance arrangements and involve missiles which do not have offensive nuclear capabilities.

to sell missiles in large quantities to many nations; our Ambassador in Paris attributes the Israeli arrangement to the "special relationship" between the nations involved. Japan has sold ten small Kappa sounding rockets to Indonesia, but present indications are that exports of more powerful rockets such as Lambdas or Mus are not planned, and that Japan appears to recognize the problem of missile proliferation.

The U.S. and the Soviet Union are by far more advanced in the missile and space rocket fields than other nations, and are considered in this study from the viewpoint of their present and potential influence on missile proliferation.* In terms of supplying missiles, the Soviets have not, in general, been following a policy of exporting significant offensive missile or rocket-related technology or components outside their borders, nor have they significantly helped other countries (including the satellites) to develop large rockets or missiles by exporting related technology. While the Soviets tend to seek markets for their obsolescent armaments, they have not assisted nations in ballistic missile or space rocket R&D or production.

To be sure, Soviet assistance to China in the 1950's is an important exception, but this was terminated in mid-1960, and does not invalidate the general pattern. Cuba appears to be a dramatic exception but in that case the missiles were under Soviet control. Rumors of the introduction of Soviet IRBMs into Indonesia have not been substantiated. The Soviets have supplied FROG and SCUD missiles to Hungary, East Germany, and Poland. Of these two rockets, the SCUD (SS-1) missile is the most powerful with a range of about 150 miles; the nuclear warhead is under Soviet control. The Soviets have provided devensive surface-to-air missiles to a number of countries in Eastern Europe and elsewhere. [redacted] 3.3 (b)(1)

*A discussion of U.S. policies and programs related to missile proliferation including such matters as training and assistance provided under cooperative space or military assistance programs, the implications of U.S. commercial exports, and the ability to detect Nth country missile programs is presented in Section C.

b. Dissemination Pressures

Nth country purchases of ballistic missile systems could become the principal mode of missile proliferation, and could cause serious problems. The [redacted] missile arrangement is an example of this. [redacted] 3.3 (b)(1) (2)(6)

The problem of indiscriminate missile transfers is not yet critical. However, there appear to be commercial, military, and scientific pressures building up towards missile proliferation. Unless major supplier nations are willing and able to establish and enforce appropriate policies, exports of rockets and rocket-related components may increase dramatically in the next five years. As an additional aspect of the problem, it should be noted that, even though missiles will become more easily obtainable, many nations might nevertheless prefer to develop an indigenous missile production capability in spite of its cost and difficulty in order to remain as independent as possible in the face of changing political and military factors.

A brief analysis* of the export laws of other nations indicates that virtually all nations with advanced technology have some procedures to control missile and rocket-related hardware. However, only a few control shipments of technical data, and only one has control over shipments by subsidiary firms located abroad and over transshipments to non-Communist nations. To the extent that nations desiring to prevent the export of missiles, rockets, and related items and data have inadequate control mechanisms, control of missile proliferation will be made more difficult. Moreover, there does not seem to be an opprobrium on transferring missiles or missile technology comparable to that on nuclear weapons. In part, this could be due to the peaceful and scientific aspects of space research, and in part due to the fact that missiles without nuclear warheads tend to be viewed as "conventional" weapons such as aircraft.

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*Performed by ACDA's General Counsel's Office

c. Utility of Purchased Missiles

A nation purchasing or otherwise obtaining ballistic missiles or space rockets, does not acquire the ability to produce missiles. Some useful design and engineering knowledge can be obtained by disassembling rockets and analyzing propellant and material composition.* However, much of this sort of information is available in open sources. It should also be recognized that the principal problem faced by nations with fairly advanced rocket capabilities in undertaking a missile program is establishing the specific production facilities and investing their resources in a large-scale program. Knowledge of basic design and engineering data would not therefore appear significantly to increase the ability of such nations to produce ballistic missile systems. Alternatively, nations with primitive rocket capabilities, limited resources, and an unsophisticated industrial base are so far away from being able to produce a nuclear-capable ballistic missile, that the knowledge acquired would not appreciably affect this situation. Moreover, such nations would have difficulty analyzing the items.

Joint production and testing programs involving conventional missiles (e.g., NATO Hawk) and general R&D cooperation with nations in the missile field transmit some information and operational skills to Nth countries. Nations purchasing and utilizing space rockets acquire operating capabilities, including tracking, data processing, launching, and maintenance capabilities. Missile transfer arrangements, under NATO for example, usually involve operational training and maintenance assistance, and limited facilities for overhaul, support, and maintenance have been established under U.S. military sales and grant arrangements. However, in view of the kinds of missiles and rockets involved and the fact that production capabilities are not transmitted, no significant missile proliferation problems seem to be raised by the above kinds of activities as they are presently structured.

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*DOD/ODDR & E, in analyzing [redacted] however, the general question of "reverse-engineering" for rockets--i.e., producing a rocket by working from the end item only without having blueprints, production specifications or equipment, etc.--has not been studied. 3.3 (b)(1)(6)

In considering the implications of missile and rocket sales, the question of how receiver nations might utilize the end-items arises. Missiles supplied by the U.S. or the Soviet Union do not represent significant problems, because of the nature and context of the transfers involved. With respect to the future French sale of missiles to Israel, nothing can be said at the present time. However as suggested earlier, potential "missile" suppliers show indications of concern with the problem of the use of supplied items. In the space field, the U.S.* and some other suppliers account for the appropriate expenditure of the rockets provided. In the U.S. case, U.S. personnel either perform or assist in the launchings, or are present at the launch site in most instances.

Thus, it appears that if the present patterns continue, Nth countries might not be able easily to "stockpile" or even misuse supplied rockets or missiles. However, if some space rocket stockpiling does occur, conversion to ballistic missiles would not easily or automatically follow (as discussed above). If large ballistic missile systems are purchased directly, such systems are difficult to maintain and operate, particularly with respect to the ground support equipment. Therefore, Nth countries might not be able to utilize acquired missiles, and might find it necessary to ask for assistance.

C. RELEVANT U.S. PROGRAMS

This section discusses U.S. programs and activities in the commercial, military, space, and intelligence areas, with emphasis on rockets and missiles.

1. Commercial Exports

Rocket-related components, equipment, and technical data are exported from the U.S. through commercial channels. Most

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*Section C discusses relevant aspects of U.S. space rocket and missile transfers.

such items are subject to export control in which each shipment must be licensed by the government. Missiles, components, and technical data, if not subject to security restrictions, come within this control.* All space research rockets and many related items are subject to export control and are generally transferred as part of agreed NASA programs. Powerful space rockets are subject to export control and are not generally commercially available from the U.S., except in limited numbers or as part of cooperative space programs.** Ballistic missiles (e.g., Pershings) are not exported privately but by DOD under military sales arrangements with other governments.

The U.S., because of its advanced capabilities, exports more rocket-related items than any other nations. Even though obvious commercially available rocket items are subject to control and are generally exported only selectively, there is a cumulative proliferation effect due to the outflow of large quantities of missile-related items which are either dual-purpose or which appear unrelated to missile production or testing when viewed individually.

Detailed export figures are difficult to obtain. About half of the $3 billion in military-related sales orders in the period 1962 through 1964 were directly related to aerospace industries, but the bulk of these exports were in the aircraft area. The volume of private (i.e., "commercial") sales of all military-related equipment compared with DOD sales is generally small, and this is probably true of missile-related items as well.

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*This does not apply if the government is the source of the shipment and/or handles transportation, as would be the case for items subject to security restrictions.

**A well-known example of a commercially available rocket is the Cubic Corporation's Forrester satellite launch vehicle; none has yet been exported.

However, assessing the significance of U.S. commercial rocket exports on the basis of gross military sales quantities and dollar values may be misleading. Rather, the kinds of items exported are significant, since missile and rocket production is based on sophisticated technology and tends to be critically dependent on particular components or test equipment--not necessarily on the quantities of items obtained.

The magnitude and impact abroad of U.S. missile-related exports and assistance through company channels may be inferred by considering the dependency of the missile programs of other nations on U.S. exports. The CIA has estimated that Western European nations, particularly the French over the past years, depend heavily on the support they receive from the U.S. through purchases of U.S. equipment and technology and interactions with U.S. firms. 3.3(b)(1)

More specifically, a [redacted] report on Western European space programs* states that "the rate at which. . .(ELDO and ESRO) progress towards their modest goals /to build a satellite launch vehicle and satellite respectively/will continue to depend heavily on the support they receive from the U.S., both officially--in joint endeavors with NASA, and unofficially--through continued purchases of U.S. equipment and technology." This same report goes on to say that although export licenses for obvious rocket-related items such as propellants and guidance components have only been granted selectively, "the export of ballistic missiles technology occurs 'in bulk' via normal commercial channels. . .(and) multimillion dollar annual sales to West European nations include quantities of missile components and of research, development, and test equipment, as well as visits of U.S. technicians and engineers to install, calibrate, and service this equipment." The report concludes by stating, "...the assistance of the U.S.... has been, is, and will probably remain the critical factor in the success of any European space program during this decade."

2. Military Sales

The present planned military sales and assistance programs do not appear to be a major problem with respect to

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[redacted] 3.3 (b)(6)

proliferation of nuclear-capable ballistic missiles. The emphasis is on aircraft, tanks, and associated logistics, and providing SAMs and other battlefield missiles to complete NATO force requirements. There are no joint R&D programs affecting nuclear-capable ballistic missiles. All U.S. military sales programs are coordinated within the government and are subject to high-level policy decisions. Exports associated with these programs may flow either through approved commercial or military channels.*

[redacted]

3.3
(b)
(1,2,6)

During the last five years, U.S. military transfer efforts have shifted from reliance on grant aid to emphasis on bilateral sales arrangements. The major exception to this policy is the cooperative NATO <u>production</u> of ASMs, AAMs, and SAMs, which was established about four years ago. The NATO Hawk production consortium did, in its early days, considerably help to provide Western European nations, particularly France, with the basis for advanced missile production, but the level of technology in Europe has now exceeded this. Of late, however, the U.S. has been considering moving in the direction of increased emphasis on joint weapons production. European nations in particular and other fairly industrialized nations

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* Concerning classified data, the U.S. Military Information Control Committee (U.S. MICC) establishes classification guidelines and declassification criteria.

of the world are now interested in developing indigenous weapons production capabilities and do not wish to continue to rely on external suppliers. Secretary McNamara, consistent with this movement, has recently suggested that NATO undertake a weapons production-sharing program.

If, in the future, the concept of joint arms production is implemented on a large scale and joint production of ballistic missiles is undertaken, it could have an adverse effect on missile proliferation unless appropriately controlled. It might be more desirable for the U.S. to sell complete missile systems rather than to enter into production arrangements whereby other nations could acquire from the U.S. specific skills and special-purpose equipment and thus develop an indigenous missile production capability (as in the case of the Hawk program in France). Limited numbers of certain kinds of missiles could, when necessary for political and/or military reasons, be provided to other nations and placed under some sort of "two-key" arrangement or subjected to deployment restrictions as a method of "safeguarding" their use.* This approach could help dissuade a nation from investing its own resources in production and would help limit the number of missile suppliers in the world.

3. NASA International Programs

NASA's cooperative international space rocket programs involve sounding rocket probes and satellite experiments using U.S. launch vehicles. Projects with other nations do not involve collaboration in booster technology, and rocket production information is not transmitted. The programs are bilateral, with both U.S. and the cooperating nation providing its share towards a mutually beneficial space research experiment through supplying hardware and equipment; no transfer of funds occurs, and no U.S. aid or assistance (as in military assistance) is given.

Most of NASA's rocket experiments utilize small research rockets which do not have the "strategic nuclear" payload capabilities of interest in this study, and most of these rockets have virtually no military capability in any sense. NASA verifies the expenditure of each sounding rocket, often by having

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*The Thor missiles once deployed in Europe were controlled by a "two-key" system.

observers present at the launch site, and there is no "stockpiling" of these rockets by recipient nations. With regard to satellite launch vehicles, the general pattern has been for nations to provide satellites for launching by U.S. owned and operated rockets. The recent San Marco Project with Italy, on the other hand, involved the orbiting of a satellite by an Italian crew (trained by U.S. personnel) using a U.S.-supplied rocket (a Scout) and a "floating" launch platform developed by Italy. U.S. observers were at the launch site, and expenditure was verified.

Due to the nature and scope of present NASA programs, there appear to be no dangers from the viewpoint of missile proliferation. Nations do not acquire the ability to produce rockets, stockpiling does not occur, and knowledge gained by learning how to launch research rockets does not contribute significantly to the technology and skills needed to develop missiles or convert rockets. In the NASA context as well as the military sales context, it is acquisition of rocket <u>production</u> capabilities which constitutes the most significant proliferation problem. In its advisory role with respect to export cases, NASA has recognized this and suggested numerous "conditions" which should or could be applied to export approvals.

On the other hand, from the viewpoint of utilizing peaceful space rocket cooperation as a means of "controlling" or "sublimating" potential missile proliferation, current U.S. programs and policies might be improved. The bilateral approach now emphasized tends more to encourage national space programs with greater potentials for diversion to military uses than do multilateral arrangements. Moreover, through multilateral space rocket cooperation, nations can profit from the pooling of resources leading to more extensive programs which can result in greater benefits to each participant than if each undertook its own small-scale project.

Cooperative space programs could be expanded to include transfers of rocket technology under "safeguarded" arrangements to guard against diversion of the equipment and facilities to military purposes (i.e., the development of missiles.) This kind of cooperation, in contrast to the present experimental orientation, can open up opportunities for arrangements with advanced nations or groups of nations (e.g., ELDO) where the problems of both nuclear and missile proliferation are more critical, and where nations could profit greatly from the prestige of a successful large-scale space program. The U.S. could take the lead in establishing precedents and procedures for safeguarded rocket cooperation. Finally, to reinforce the foregoing, it would appear useful to consider providing credit arrangements or grants to nations in order to help them further their space endeavors, while offering increased opportunities to help direct Nth country rocket efforts along peaceful lines through U.S. involvement in their programs.

4. Unilateral Intelligence

Knowledge of the status and potentialities of Nth country rocket and missile programs is an important aspect of the missile proliferation question, since such information can assist U.S. policymakers in deciding on courses of action which might be taken to retard the spread of missiles. Intelligence analysis can support U.S. unilateral policies by pointing out, where possible, the technical or economic problems in Nth country missile or rocket programs, and by assessing, however grossly, the magnitude and impact of U.S. exports and assistance. And, technical analyses of the possible significance of particular items--in light of specific Nth country rocket programs--contribute to the evaluation of individual export license cases. Intelligence can also assist in gaining an understanding of the policies and practices of Nth countries regarding their export and assistance programs. Additionally, unilateral intelligence will contribute to U.S. requirements for and ability to verify arms control measures affecting Nth country missiles.

3.3 (b)(1)

[redacted]

3.3(b)(1)

[redacted]

In view of the foregoing discussion, it would be in the interest of the U.S. Government to improve as much as possible our Nth country missile and rocket intelligence capabilities and to give higher priority to these concerns within the intelligence community. The Non-Soviet Working Group of GMAIC* should continue to assign increasing priority to the missile proliferation problem.

D. POLICY IMPLICATIONS

This section discusses present U.S. unilateral policies relating to missile proliferation, and highlights the purpose and nature of arms control in this context.

1. Missile Proliferation Policies

The single, most relevant unilateral policy affecting missile proliferation is contained in NSAM 294 which states that U.S. policy is not to provide significant direct assistance to national strategic nuclear forces, specifying France in particular. This policy is now being interpreted as applying to all nations,** although the NSAM has not yet been redrafted formally to express this expanded interpretation. NSAM 294 policy affects nuclear weapons and delivery vehicles (including ballistic missiles, rocket components, and related data). Within its scope are relevant U.S. commercial exports, cooperative space programs, and military assistance and sales arrangements.

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*Guided Missile and Astronautics Intelligence Committee of USIB.

[redacted]

3.3(b)(6)

There exists a number of more or less ad hoc U.S. policies related to missile proliferation. Present U.S. policy toward the Middle East is to refrain from becoming a major supplier of arms to the area, to oppose proliferation of nuclear weapons and missiles, and to make occasional exceptional sales to meet defense needs and preserve stability (e.g., sales of Hawk air-defense missiles to Israel). U.S. policy toward Latin America is to attempt to avoid introducing into the region sophisticated offensive weapons, particularly advance aircraft (but, by inference, also ballistic missiles). The Indian and Japanese Working Groups of the Thompson Committee on Non-proliferation also deal with matters bearing on missile proliferation policies.

It would appear that the concerted effort of the U.S. Government growing out of NSAM 294 could become the central unilateral mechanism for implementing missile proliferation policies and coordinating the various commercial, political, military, and space aspects. Furthermore, for purposes of policy clarification and to enhance its impact, it would be useful to redraft the NSAM to express formally its applicability to all countries.

It would also be desirable for U.S. missile and advanced weapons transfer policies toward particular regions of the world, such as Latin American and the Middle East, to be brought within common policy guidelines, with due recognition of regional and country differences. This would necessitate appropriate definitions of "strategic" in small-power situations where nations are in close proximity. If "strategic" is only taken to be "nuclear", however, there could be problems in terms of narrowly interpreting this U.S. policy by not applying it to missiles and rockets which, though not nuclear-capable, can contribute to a nuclear missile capability. It would, therefore, seem advisable to cause a systematic review to be undertaken of this entire area, dealing with conventional missiles and research rockets.

In defining and enforcing unilateral policies affecting missile transfers, numerous factors are taken into account by U.S. policymakers. These factors include the technical capabilities of the foreign nation involved; the alternative availability of components and assistance; U.S. hardware and data currently in the hands of the foreign countries; ongoing data exchange and military agreements; the situation of foreign subsidiaries and licensees of the U.S. companies; and the effect on the U.S. economy in terms of competitive position and balance of payments. The interpretation and implementation of these policies vary from country to country, and decisions tend to be made on a case-by-case basis.

The NSAM 294 Working Group has analyzed U.S. export laws and mechanisms, relevant programs, and the various factors affecting enforcement. The Working Group has highlighted many problems relating to enforcing U.S. unilateral policy under NSAM 294. For instance, agencies involved had differing interpretations and used different criteria, and interagency coordination was not adequate. Nevertheless, a number of matters relating to enforcement of missile proliferation policies have not been adequately dealt with and are discussed below. However, it should be recognized that the success of U.S. missile non-proliferation efforts depends less on enforcement mechanisms than on the <u>policies</u> guiding the application of these mechanisms. In particular, the <u>priority</u> given to the actual "non-proliferation" thrust of our policies needs to be increased in comparison with other high-level (but sometimes countervailing) policy considerations such as our balance-of-payments situation.

2. <u>Policy Effectiveness</u>

The NSAM 294 Working Group concluded that U.S. export laws governing the control of export of missiles and related items and information from the U.S. are generally adequate, and no additional regulations are needed. Certain legal "holes" in U.S. export mechanisms have been identified and actions are being taken. For instance, the problem of proliferation of missile technology through connections between U.S. firms, subsidiaries abroad, and foreign companies is being studied as dictated by NSAM 326. However, the legal aspects of re-export controls and transhipment have been only briefly examined under NSAM 294, and more study is needed. Also, the export laws of other nations were not analyzed, and, in the case of both the U.S. and other advanced nations of the West, it appears necessary to explore possible loopholes in transhipment and re-export laws to non-bloc areas, where many of these regulations have not heretofore been successfully applied.*

There are proliferation problems caused by the availability of unclassified rocket information and rocket experts visiting and working in other nations. Although companies and individuals are required to report all contacts concerning potential military sales to foreign nations to the Office of Munitions Control, there appears to be some room for improvement in the controls over foreign weapons work by personnel under U.S. jurisdiction.** Also, there could be a danger that the U.S. is declassifying missile-related information on the basis of Soviet capabilities and consistent with U.S. policy towards the Soviet Union, and that not enough attention is being given to the Nth country missile situation.***

In order to increase the efficiency of U.S. export control mechanisms, it might be advisable to review periodically the various export lists to incorporate technological changes, and to prepare "handbooks" which could serve as policy guidelines. Furthermore, recognition should continue to be given to controlling equipment and information relevant to ground support, testing, and production associated with rockets, in addition to rockets and components per se. It would also seem advisable to consider establishing a centralized filing system for rocket-related export data to improve inter-agency coordination, facilitate statistical analyses, and help estimate the cumulative impact of U.S. rocket exports.****

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*There are existing multilateral export arrangements directed towards the Middle East (which are not too successful) but there are no multilateral restrictions directed toward non-bloc countries such as those directed toward the Soviet bloc countries.

**ACDA's General Counsel's Office is studying this problem in addition to the question of export laws of other nations.

***The recent export license case concerning the Douglas Corporation assisting the Japanese company of Mitsubishi in liquid-rocket technology indicated, for example, that virtually all of THOR missile technology has been declassified; U.S. MICC would appear to be the mechanism best suited to examing the broad issue involved.

****The erstwhile State-Defense Coordinating Committee on Military sales was a particularly useful coordinating mechanism.

Technical studies are needed to support U.S. enforcement of rocket exports and as part of the overall missile non-proliferation effort. A broad study of the question of "reverse-engineering" for rockets (i.e., the extent to which analyses of end-items provides knowledge relating to the production of the item) can assist in our understanding of the spread of rocket production capabilities through rocket sales. The feasibility of applying "two-key" systems to ballistic missiles transferred to other nations should also be explored along with the possibility of developing ways of helping to verify that rocket components sold commercially or transferred under military arrangements are used for agreed purposes.* In addition, based on ACDA's work in describing "critical items" in the context of the freeze and other arms control agreements, a comprehensive study of the applicability of this concept to export control should be undertaken.**

A final factor relating to the effectiveness of U.S. unilateral policies deals with the question of the dependency of other nations on U.S. exports and assistance. In certain instances the U.S. may decide that it is in its net interest selectively to "proliferate" particular missile items or technology to specific nations because alternate suppliers are available or the nation involved is self-sufficient. Export decisions also tend to be made by balancing whether U.S. export denials would "significantly" affect another nation's missile or space capabilities against the possibility of such prohibitions having a marginal technical effect with counter-productive political or economic results.

It could well be, however, that the relative inability of the U.S. to prevent missile proliferation is given unwarranted

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*ACDA's Weapons Evaluation and Control Bureau is performing an initial study of controls over the use of armaments provided through U.S. military assistance.

**In support of recent NSAM 294 activities, DOD/ODDR&E has already suggested six "critical areas" of technology which can be well-defined and which would appear to be significant if allowed to flow to France.

weight in policy decisions. It was concluded earlier that it is difficult for Nth countries to produce ballistic missiles for their own use and to sell to other nations. This point has been further underscored by the degree of dependence on the U.S. by advanced nations of Western Europe in the missile and rocket field. Additionally, as suggested in the previous discussion of Soviet policy, the argument that the Soviet Union will be an alternate supplier for a wide variety of weapons if the U.S. fails to provide support does not necessarily apply in the area of offensive ballistic missiles. Thus, in more instances than presently assumed, it is probable that U.S. prohibitions can adversely affect Nth country missile programs and, alternatively, selected and "safeguarded" U.S. involvement in peaceful rather than military programs can help ensure the success of the former.

3. Arms Control Policies

Unilateral U.S. policies alone cannot be expected to achieve desired missile non-proliferation goals. Bilateral and multilateral efforts must be pursued as a complementary part of unilateral policies. U.S. policies cannot always prevent certain nations from obtaining missile systems, related components, or production capabilities from other suppliers; therefore, it would be in our interest to attempt to enter into formal or informal arms control arrangements. Efforts to retard or control missile proliferation appear feasible on the basis of this study, which concludes that it is difficult to produce ballistic missiles, and, because of this and other factors, missile proliferation may not be inevitable. The desirability of undertaking such efforts has also been indicated.

In attempting to pursue multilateral solutions to the missile proliferation problem, the question of allowing for and defining "good" missiles (i.e., space rockets and defensive and small tactical missiles) versus "bad" missiles must be considered. Focusing on strategic nuclear ballistic missiles seems reasonable, even though the interpretation of "strategic" varies. In addition, the kinds of proliferation which are of concern should be articulated; controlled or "safeguarded" missile transfers might not present the dangers associated with uncontrolled, indiscriminate proliferation. Furthermore, it should be recognized that efforts by the U.S. in concert with other major powers to restrict the freedom of action of smaller countries in the field of missiles and rockets--in addition to nuclear weapons--runs the risk of being counterproductive and exacerbating feelings on the part of non-nuclear nations that they are being discriminated against.

Some examples of arms control measures which might be explored are as follows:

--Supplier/receiver arrangements which would freeze the offensive missile situation in critical regions such as the Middle East.

--Missile-free zones in Latin America and Africa, perhaps associated with nuclear-free zones.

--A non-dissemination agreement affecting strategic missiles only (this could be within the broader context of an SDV non-dissemination measure), or a non-dissemination agreement affecting all nuclear-capable surface-to-surface ballistic missiles: these could be separate measures or coupled with a nuclear-non-proliferation agreement.

--A U.S.-Soviet "bonfire" of obsolete missiles and rockets to be included as part of the "bomber bonfire" proposal.

--A U.N. resolution calling for international cooperation to prevent the indiscriminate spread of nuclear-capable missiles (and aircraft) to reinforce nuclear non-proliferation efforts; associated with this could be informal attempts by the U.S. to convince other suppliers to increase the policy priority and effectiveness of their export controls over missile (and aircraft) components.

It is also important to examine the question of "safeguarding" the transfers of rockets and technology as another aspect of missile non-proliferation. Nations have legitimate desires in the space field, and many nations will eventually obtain rocket capabilities. Safeguarded rocket assistance and cooperation can offer peaceful alternatives to military missile programs, while at the same time, through appropriate technical, economic and political involvements, can make it difficult, costly, or unattractive for nations to divert their space programs. Even though safeguarded arrangements might not be able to prevent a determined nation from pursuing military designs, at worst it can provide "early warning" and offer some deterrence to nations. Moreover, safeguarded rocket programs can strengthen non-proliferation efforts by establishing the principle that arms control can be constructive and positive, not only prohibitive, and thus help alleviate the discrimination problem.

With respect to the technical feasibility of rocket safeguards, ACDA and NASA have begun to study the question of technical controls over rocket proliferation.* Such controls could be used to support unilateral export enforcement and bilateral cooperative efforts as well as multilateral space rocket arrangements. Systematic studies of the military, political and legal ramifications of safeguarded rocket transfers, however, are needed.

To the extent that the United States and other supplier nations pursue vigorously peaceful multilateral and international space rocket programs under safeguarded arrangements they can offer peaceful alternatives to potential military programs.** As one suggestion, the concept of an International Space Agency which could provide sounding rockets and satellite launch vehicles under safeguarded arrangements and/or regional agencies along the same lines should be investigated. Also, the U.S. should study the question of establishing international satellite launching facilities,*** and might also investigate the

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*The Arms Control Group at Jet Propulsion Laboratories is undertaking a study of this problem.
**Precedents for international space cooperation already exist; in addition to the many activities of the U.N. Committee on the Peaceful Uses of Outer Space, UNESCO has discussed the idea of selling sounding rockets to nations for research purposes, and world-wide coordinated sounding rocket programs have been instituted through COSPAR.
***The Thumba international sounding rocket launch site in India, sponsored by the U.N., is already functioning; however, it is not well-located for satellite launchings.

desirability and feasibility of developing a worldwide network of tracking stations under U.N. auspices for purposes of data exchange and to help verify peaceful uses arrangements. In addition, the U.S. should place renewed emphasis on full, worldwide utilization of the U.N. resolution calling for declarations and registrations of space launchings, and might consider extending it to include invitational launch site visits.

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ANNEX: SURVEY OF Nth COUNTRY MISSILE CAPABILITIES

To provide background for the main paper on missile proliferation, this Annex briefly describes the missile and space rocket capabilities of selected Nth countries. Present (and, where applicable, future) capabilities are discussed, and related matters of particular importance are highlighted. Nations not discussed do not have a missile or rocket capability which could lead to the development of nuclear-capable surface-to-surface ballistic missiles within the next decade.

France

The French Mirage aircraft will be supplemented by a hardened land-based IRBM which is under development and will probably be deployed beginning in late 1967. By 1975, this missile force will probably grow into a mixture of land-based IRBMs and sub-launched ballistic missiles. The land-based IRBM will probably be a two-stage solid rocket missile, and it is believed that by the end of 1967 the French will have nuclear warheads capable of being carried by these missiles. These missiles, although not as accurate or reliable as U.S. missiles, are felt by the French to be sufficient for a second-strike countervalue deterrent. The French are developing a satellite launch vehicle, the Diamant, and are developing the second stage booster for the ELDO satellite launch vehicle. It is expected that the French will attempt to place satellites into orbit sometime during 1965 or early '66. Although the French missile programs are now formally separated, they still remain intertwined through an industrial network and as a result of dual-purpose technical developments (e.g., boosters).

The French have received past support--both directly and indirectly--from the United States in the development of their rocket and missile capability, but the impact of the NSAM 294 policy has reduced this support to a minimum. French policy is to attempt to develop an indigenous capability and to purchase equipment from the U.S. only where absolutely necessary, but the French pursue the acquisition of information from U.S. firms and subsidiaries. The French facility now producing solid propellants was involved in the NATO Hawk missile production program and assistance was given by U.S. engineers; the French gained considerably in the solid propellant field from this program. In March of 1964, the French purchased in the U.S. a large, modern, glass filament case winding machine capable of winding cases for large solid rocket motors. Although present French missile capability is high, French firms connected with the IRBM program are encountering major technical problems but will not overtly admit being in trouble. These problems seem to be in the general areas of guidance, re-entry, tracking, and hardened silo construction.

Under NSAM 294 policy, the U.S. has been attempting to stop contributing to the French nuclear force. At this stage, however, there is probably little that the U.S. can do to affect significantly the eventual attainment by France of a ballistic missile capability. The U.S. can retard and make more costly the French program, and perhaps have an effect on reducing the quality of the resultant missiles. The U.S. continues to have joint scientific space experiments with the French, (e.g., orbiting a French satellite using a U.S. booster), and continues to selectively release data and equipment, particularly in the area of non-storable liquid rocket technology (since this is clearly for the French space program).

The French, having a missile production capability, are potential suppliers of missiles and rockets to other nations. The Israeli government has arranged to purchase surface-to-surface missiles capable of carrying a nuclear warhead (1,300 lb. payload) over 250 miles now being developed by a French firm. Israel appears to be assisting this development program by supplying certain components.

China

It is estimated that the Chinese are developing an MRBM similar to the Soviet SS-4, and that a few such missiles could be ready for deployment, with associated fission warheads, by 1967 or 68. Although the Chinese may have a submarine which appears to be able to launch (from the surface) 350 n.m. ballistic missiles, it is not known what missiles they expect to use. It is also estimated that the Chinese could not deploy an operational ICBM system before 1970 nor could they develop a significant missile-capable submarine threat to the U.S. until well into the 1970's.

Japan

Since 1955 the Japanese have been developing solid-fueled sounding rockets, from the small KAPPAs to the larger LAMBDAs. They have continued booster development and, having progressed through four generations of rockets, now have a still more powerful solid booster (the MU), which will give the Japanese a guided rocket capable of placing satellites in orbit; a satellite launch attempt is planned in late 1965. Japan has spent a total of $50 million thus far in its space program, and might spend an additional $120 million by 1970 as satellite rocket systems are produced and utilized.

The diameter and thrust of the MU booster would place the vehicle in the IRBM/ICBM category. Although it does not appear that any official Japanese "requirements" for a long range missile exist, a plan for conversion of space rockets to MR/IRBMs is being considered by a group of Japanese scientists who are influential in strategic policy planning. Conversion of the new booster and rocket into a military missile is particularly dependent upon developing guidance and control systems, modifying ground support equipment, and undertaking a two to three year period of extensive flight testing. It is estimated that a military version of the MU rocket could not reach operational status before 1969. The development cost of conversion would be about $500 million ($200 to $300 million of development and test could be done as part of the space effort), and a force of 200 IRBMs with 100 soft sites could be produced and deployed for $1-2 billion. (Of course, since much missiles would probably not be useful for Japan in a conventional role, developing or obtaining a nuclear warhead would be an obvious problem.)

The Japanese have proceeded through many generations of rockets and are anxious to obtain an independent space capability. Although some military stirrings exist in Japan, Prime Minister Sato and Professor Itokawa both have agreed that an acceleration of the Japanese satellite project would be a non-military method of demonstrating Japanese scientific superiority in Asia. Itokawa himself has said that this development would be a "safe, sane, peaceful, dramatic, non-controversial, manageable, and rational method."

The proposed arrangement between Douglas Aircraft Company and the Mitsubishi Corporation, involving THOR (non-storable, liquid-fueled) missile technology, has been approved by the U.S. Government. This is the first instance of Japan asking for substantial U.S. support, and reflects the relatively primitive state of Japanese liquid-rocket capabilities.

Since Japan has a fairly advanced indigenous capability, she has already begun looking for markets for her smaller sounding rockets. In general, the Japanese seem to be responsibly considering the potential military impact of their smaller rocket sales and appear to realize the potential problems associated with sales of large rockets. Indonesia has purchased 10 KAPPA sounding rockets from Japan, and at least two have been fired. In agreeing to this sale, Japan has asked Indonesia to join COSPAR and declare that the rockets will be used only for peaceful, scientific purposes; also, there are indications that the Japanese have considered sending "observers" to the KAPPA launches. The Indonesians also requested LAMBDA rockets; no sales of LAMBDA's have been made, and present Japanese policy appears to be opposed to such sales in general. Yugoslavia has received KAPPA rockets and other countries have negotiated with the Japanese but no other transactions have occurred. Solid propellants for small research rockets are being manufactured in Argentina under special permit from the Japanese.

West Germany

In the larger rocket area, German industrial and Governmental interest is currently focused on the development of a third stage liquid-booster for the ELDO space vehicle. In addition to having the industrial facilities for production of the stage for the booster and the propellants, West Germany has relatively advanced guidance and control capabilities, and a small testing range. Germany is also equipped with a number of American military missile systems under NATO arrangements and for fulfilling NATO force goals. Some missiles are co-produced, and there are repair and maintenance facilities for certain missiles. However, these latter missiles are AAMs and SAMs, such as Sidewinder and Hawk; production facilities for nuclear-capable surface-to-surface missiles, such as Pershings, do not exist in Germany.

The Germans have recently expressed interest in a cooperative program with the U.S. to develop advanced inertial guidance systems. These guidance systems would be of ICBM quality, although not packaged for use in missiles. The Department of State and DOD, after considering the implications of such a cooperative program when broadly interpreting NSAM 294, nevertheless decided that the U.S. should cooperate with the FRG. In addition, the West German Defense Ministry has contracted with a French firm for the development of two medium range air-to-surface guided missiles for the F-104 aircraft. This missile is not a significant ballistic missile threat of course, but represents the potential movement of the Germans away from the U.S. if we do not supply appropriate weapons for them.

It is estimated that the FRG could develop a liquid-fueled ICBM in from three to four years. However, production of "guided missiles and components" (surface-to-surface type) are renounced by the FRG in the Brussels Treaty (WEU restrictions) in addition to prohibitions on the manufacture of CB and nuclear weapons. There has, however, been concern expressed over the last two years in the U.S. Government and by NATO nations, and of course, the Soviet Union that the FRG has already violated--or at least severly "eroded"--the WEU restrictions on the basis of its missile programs.

It is clear that the West Germans have the capability to produce larger military missile systems if they so desired. However, in a fairly detailed evaluation of the situation, our Ambassador in Germany has stated that there is no evidence of any serious thought or developments in West Germany leading to a program for the research, development, and production of long-range guided military missiles. The nuclear weapon restrictions of the WEU, it could be argued, make it unlikely that the FRG would consider developing nuclear-capable missiles. And, blatant violation of missile production restrictions would probably have serious repercussions (unless the WEU members might want the FRG to produce missiles in support of some European nuclear force). Moreover, it appears that as long as the German leaders are convinced that U.S. missiles will be deployed to protect German territory and/or that U.S. missiles can be purchased by the FRG, the question of German production of such delivery systems may not be serious at the present time.

The United Kingdom

The U.K.'s major national program is organized around cooperative arrangements with NASA involving instrumented sounding rocket launchings and launchings of British satellites. Except for the Blue Streak project, which is no longer part of a military program but involved in ELDO, there are no indications that the U.K. will expand its existing large rocket programs. Due to company connections and British involvement in ELDO, virtually all of the technology and experience associated with the Blue Streak which was obtained from the U.S. is probably known to most European countries.

The U.K.'s adverse experience in attempting to develop the Blue Streak into an MRBM indicates that even such a technically advanced nation finds it extremely difficult, and in this instance, undesirable and unfeasible, to produce its own nuclear-capable ballistic missile system. Britain will apparently satisfy her nuclear force goals by continued reliance on bomber aircraft, purchasing POLARIS missiles from the U.S., and attempting to establish the ANF.

India

[redacted] India has no rocket production capability to speak of, and does not have the broad, sophisticated (e.g., electronics) industrial base of a country like Japan needed for development of a rocket system of appreciable size.

3.3 (b) (1,6)

With possibly increased emphasis since the Chinese nuclear test, India has begun to be more concerned with the rocket question. The French are to build a production facility for solid-fueled meterologic rockets (the Centaure) in India, [redacted]

3.3 (b) (1,6)

3.3(b)(1,6)

[redacted]

The U.S. has a bilateral agreement with India involving launchings of meteorological rockets. Establishing more extensive cooperative space programs which might provide India with a peaceful show of strength (e.g., satellite launch) have been considered within the U.S. Government. India has already achieved international prestige benefits from having the UN-sponsored Thumba sounding rocket launch facility on her soil. NASA has considered working out an arrangement to launch an Indian satellite with a U.S. vehicle.

Israel

The Israelis have contracted with the French to purchase a two-stage solid-propellant missile employing inertial guidance and having a range of about 270 nautical miles. The vehicle can carry a 1,300 lb. conventional warhead and is large enough to accommodate a French nuclear warhead. About 25 missiles have been ordered. [redacted]

3.3 (b) (1,6)

The Israelis have been interested in a surface-to-surface missile as early as 1961. They developed a Shavit sounding rocket, and it is believed that this rocket would be used as a basis for developing a short-range ballistic missile. However, this program has been cancelled (or delayed) due to quite a few launch failures and other problems. Israel has displayed considerable interest in securing missile technology, equipment, manpower, and related information from the U.S. In fact, in December 1962, Israel openly attempted to recruit U.S. missile scientists and engineers, and technicians to work on a crash Israeli ballistic missile program. The U.S., of course, has provided Israel with Hawk air-defense missiles.

The history of the Israeli missile program underscores the difficulties an Nth country can encounter in attempting to develop and produce a complete ballistic missile system of modest capabilities. The Israelis, although well developed technically and able to draw on a variety of external assistance, essentially discontinued their indigenous program and chose to arrange to purchase missiles from the French. This is not to say that the Israelis could not have eventually developed their own missile, but merely to indicate that although rocket technology has spread the actual development of a missile system would be a difficult and costly undertaking.

The military and political ramifications of the armaments situation in the Middle East needs no elaboration. Although the U.S. Government is concerned about this significant problem, no solutions have yet seemed feasible. Prime Minister Eshkol of Israel recently said that he would welcome an agreement whereby both the Western and Eastern nations might agree not to supply nuclear or conventional weapons to the Middle East. It should be noted that the Federal Republic has stated its intention not to negotiate further deliveries of armaments to areas of tension, particularly the UAR and Israel.

The UAR

The UAR, with the assistance of German missile experts, has been developing three types of liquid-fueled ballistic missiles, one of which (the Conqueror) could be capable of carrying a nuclear-weight payload (e.g., about 2,000 lbs.)

3.3(b)(1,6)

a distance of 200 miles with a CEP of 5-10 miles. [redacted]

3.3(b) (1,6)

[redacted] it is fairly clear that technical and economic factors are causing program slippage and could have adverse affects on the quality and quantity of missiles produced. [redacted]

3.3 (b) (1,6)

The UAR does not have a feasible nuclear weapons capability, but the potential deployment of conventionally-armed ballistic missiles against Israel would be extremely destabilizing. Israel recognizes that it presents a small, dense target, although the actual military threat of such missiles is small, and views these missiles as weapons against which it will be unable to provide a defense. Israel fears that possession of such weapons may encourage the UAR leaders to take greater risks. Prime Minister Eshkol has stated, for example, that the UAR missile program presents a danger since it is leading to the development of a "delivery vehicle for nuclear weapons if the UAR ever makes or obtains the warheads." President Nasser views the missile program as a source of world prestige in addition to its value vis-a-vis Israel. With the forthcoming Israeli purchase of French missiles, a Middle East missile race is developing.

Other Nations

Except for the San Marco project in which an Italian satellite was launched by Italians from a floating platform utilizing a Scout missile provided by the U.S., there do not appear to be any Italian space or rocket programs involving launch vehicle development. There are indications, however, that Italy is considering requesting U.S. assistance in producing a short-range solid-fueled tactical missile.

Neither Belgium nor the Netherlands has a national space program involving large sounding rockets or satellite launch vehicles, and neither produces ballistic missiles. Sweden has a fairly advanced short-range, conventional warhead missile production capability (SAMs, AAMs, ship-to-ship rockets, etc.) and has been given some U.S. assistance in developing these items. Sweden has also been conducting a small sounding rocket program in cooperation with NASA.

South Africa, Switzerland, Poland, and Australia have rocket capabilities but in the areas of short-range sounding rockets and air-to-surface and surface-to-air type small military rockets. Argentina has a small native solid-fueled rocket program, capable of launching sounding rockets up to 40 miles with payloads of five or ten pounds. Indonesia, Yugoslavia, and Mexico have extremely limited sounding rocket programs and capabilities.

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~~CONFIDENTIAL~~

UNITED STATES ARMS CONTROL AND DISARMAMENT AGENCY

nuclear weapons

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January 18, 1965

MEMORANDUM

TO: Mr. Robert Komer

FROM: Herbert Scoville, Jr. H. Sc

SUBJECT: Proliferation of Missile Capabilities

Attached for your information is a brief, general report which indicates the relative ease with which partially industrialized countries could produce simple strategic missiles of modest accuracies with ranges up to 1500 miles. This report is based upon unclassified sources only. It is related to the nuclear weapon and delivery vehicle proliferation problems, both of which are currently under study in ACDA.

Attachment

As stated

GROUP 3
Downgraded at 12 year intervals; not automatically declassified

~~CONFIDENTIAL~~

ST-2171

M. Robert Komer

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THE PROLIFERATION OF ROCKET TECHNOLOGY

A. R. HIBBS
Arms Control Study Group

January 1, 1965

Jet Propulsion Laboratory
Pasadena, California

THE PROLIFERATION OF ROCKET TECHNOLOGY

A. R. Hibbs

I. INTRODUCTION

The modern military guided missile is a highly complex device, and, in the present competitive world, it is becoming increasingly sophisticated. As the major powers attempt to maintain or to improve their position, a great deal of effort goes into improving the performance of this weapon. Specifications become steadily more demanding. The aim must be made more accurate; the survivability of the missile must be increased; the reaction time must be reduced. And so on. These demands place a heavy burden on those who build the missile. They must draw upon a vast store of past knowledge and experience and then move steadily forward to develop new techniques. The typical high-performance military missile system is, therefore, the product of an advanced and developing technology. This, in turn, involves a complex industrial base and a massive research effort.

Not all countries, however, need to compete in this league. It is possible that effective military operations could be carried out with rocket vehicles of less refined capabilities.

For example, if the government of mainland China were to acquire the ability to produce nuclear weapons, even a comparatively crude rocket-delivery system might then have a major destabilizing effect on the military balance in South Asia. It is the purpose of this paper to outline the requirements for the production of comparatively simple rocket vehicles which might be effective in such a situation.

It is not my purpose here to assess the political implications of such a weapons-development program, nor to compare the value of a rocket system to that of aircraft, but simply to attack the technical question: Can a nation of limited industrial capability produce such vehicles?

II. PROPULSION

A. Solid Propellant Rockets

All rocket propellants consist of two basic ingredients: a fuel and an oxidizer. In solid propellants, these two ingredients are mixed together and cast into a solid form. A typical oxidizer is ammonium nitrate, although ammonium perchlorate results in a more energetic propellant, and this is used in most modern formulations. The fuel acts as the binding material, giving the solid propellant structure, or "grain," its structural strength. Asphalt has been used, as has rubber. Modern propellants usually use synthetic rubber or such plastics as polyurethane.

Formulations of typical solid propellants are no longer secret and, in fact, are described in some detail in easily available textbooks.[1]

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[1] For example, ROCKET PROPELLANTS, by Francis A. Warren, Reinhold Publishing Company, New York, 1958; and ROCKET PROPULSION ELEMENTS, by George P. Sutton, John Wiley & Sons, New York, 1st Ed. 1949, 2nd Ed. 1956.

In addition to the oxidizer and fuel, a number of special ingredients are added to the propellants to obtain improvement in mechanical properties or burning characteristics. Carbon black or aluminum powder, for example, can be added to improve the performance (i.e., the impulse which a unit weight of the propellant will impart to the rocket) of a solid propellant. Some of the most recently developed and most effective additives are still under security classification; however, other such additives which have come into more common use are described in a number of sources in the open literature.

Ammonium perchlorate as an oxidizer gives a higher performance propellant than ammonium nitrate, but it is somewhat more difficult to produce. Sodium perchlorate is one of the typical precursors of ammonium perchlorate in standard chemical industry processing. This form of perchlorate can be made from sea water and air by the use of electrical power. The most commonly used process requires platinum electrodes and results in a certain loss of platinum. However, more recently a process has been patented which uses lead-oxide electrodes and which produces ammonium perchlorate from sodium chloride at a power consumption of five kilowatt hours per pound of product.[1] This process is not secret, and in fact a Peruvian company has been licensed to use a portion of this process to manufacture sodium chlorate, a close

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[1]U.S. Patent No. 2,945,791, assigned to Fred D. Gibson, Jr., Pacific Engineering and Production Company.

chemical relative of the perchlorate molecule. Another process for making ammonium perchlorate from sodium chlorate has been described by Dr. Joseph Schumacher of American Potash Company.[1]

Even though the manufacture of ammonium perchlorate appears to be a comparatively simple process for even a primitive chemical industry, it would not be necessary. Perchlorates are sold on the world market without any special restrictions, even though their only major use is in the field of explosives and rocket propellants. Thus, it would be possible for any country to purchase all of this particular propellant component.

The production of the fuel component of the solid propellant may require more experience and technique, if it is desired to have a highly efficient solid-propellant rocket motor. One of the best formulations developed in this country is polysulphide rubber, commonly known as "Thiokol" rubber, which requires a manufacturing process that is still somewhat complex. A simpler rubbery plastic material is polyurethane, and this might be more suitable for a less-well-developed chemical industry. Of course, natural rubber can be used.

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[1]U.S. Patent No. 2,511,516, "Sodium Chlorate," June 13, 1950;
U.S. Patent No. 2,512,973, "Perchlorates," June 27, 1950;
U.S. Patent No. 2,515,614, "Electrolytic Cell for Conversion of Sodium Chloride to Sodium Chlorate," July 18, 1950;
U.S. Patent No. 2,739,873, "Ammonium Perchlorate," March 27, 1956; assigned to Joseph C. Schumacher.

Once the basic materials have been obtained, the mixing, casting, and curing of a composite solid propellant does not present any difficulties. There is always a safety hazard, and an inexperienced organization would be likely to have a few accidents. However, complex machinery and a large industrial base are not required.

No exotic materials are required for the manufacture of the engine tank. High-quality steels are desirable in order to cut down the deadweight of the rocket vehicle while maintaining adequate strength in the motor case. For case-bonded, solid-propellant engines, the flame itself does not touch the case, so that there is no severe temperature problem. Specifications for the chamber do become severe, however, when high performance is required. The chamber wall must have a closely controlled, uniform thickness and concentricity.

Perhaps the most severe material requirement is for nozzles and, in particular, nozzle throat liners. Both graphite inserts and ceramic liners have been used to alleviate the problem of nozzle erosion. Here again the problem is primarily one of technique and experience rather than industrial capacity.

The most severe problems which would probably be faced by a country attempting to develop large, solid-propellant rockets without the benefit of very much experience would be connected with the problem of physical properties of the propellant and of the propellant liner. This latter material is an adhesive which cements the outside surface of the propellant grain to the motor case (for these modern, composite, case-bonded propellants which we have been discussing, burning takes place at the surface of an interior perforation, typically running through the center of the propellant grain like the inside of a bottle). Typical difficulties are cracks developing in the propellant grain itself and separation of the binder from the wall. The solution of such problems is more of an art than a science and requires time and experimentation.

In general, the manufacture of large, solid-propellant rocket engines requires time rather than industrial capability--time for experimentation and time for gaining experience with techniques of case bonding, propellant formulation, the effect of various additives, etc. Such requirements would not rule out a partially industrialized nation such as mainland China as a producer of large, solid-propellant rockets (it might be noted that the Chinese invented solid-propellant rockets some 600 years ago).

B. Liquid Propulsion

The fuel and oxidizer in a liquid-propulsion system are carried in separate tanks. The most common oxidizer is liquefied oxygen. Acid was used in the early U.S. Corporal rocket and is reported to be the oxidizer in the recently developed tactical missiles of the UAR.[1]

A variety of fuels are available, with kerosene probably being the most common. Aniline, hydrazine, and alcohol have also been used. Some advanced high-performance liquid engines, such as the Centaur stage

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[1] AVIATION WEEK AND SPACE TECHNOLOGY, September 9, 1963, p. 32. It is reported that this rocket was developed with considerable involvement of experienced German technologists.

of the Atlas-Centaur vehicle, use liquefied hydrogen. A propellant combination such as the acid-kerosene combination reported used in the UAR missile is inexpensive and requires no particularly advanced chemical industry to produce. The texts already mentioned describe such propellant combinations and give data regarding the performance that can be expected from them.

Large rocket engines capable of producing about 100,000-pound thrust require a certain amount of machine-tool and welding capability. For example, a large lathe with a two-foot swing and six-foot bed might be required and a stamp press. Other components of the system, apart from the main nozzle and thrust chamber, require smaller machine tools.

The technology involved in thrust-chamber design would be novel, particularly in connection with the design problems of the injector system. Even for modern, highly developed rockets, injector design, like some aspects of solid-propellant technology, is still more of an art than a science and can be completed only with the help of much trial-and-error testing. Improper injection of this fuel and oxidizer and subsequent improper mixing or improper burning can result in irregular combustion and the explosion of the motor. The solution of this problem requires time, but not a large industrial capability.

Other components of this system, valves, pressure regulators, turbopumps, etc., are sufficiently similar to standard, industrial, fluid-handling components, so that no special new skills are required for their design. Some testing may be required to adapt these components to the particular liquids used in the engines, but this is primarily a process of testing various materials for their durability in contact with the liquids in question. Turbopump technology, for example, is about 50 years old, and turbopump designs are standard in college textbooks.

One specialist in the liquid-propulsion field estimates[1] that the industrial complexity necessary for the successful development of large, liquid-propulsion engines is less than that required for the production of automobiles but more than that required for the production of hot-water heaters. He places it somewhere on the level of the technology required for the manufacture of motor-generator sets.

III. PROPULSION SYSTEM REQUIREMENTS

The fundamental performance problem in propulsion-system design is establishing a proper relationship between total weight, delivered-payload weight, and maximum range. For a given range and payload weight, the total weight of the fueled rocket depends upon the energy of the fuel used and the structural efficiency which can be applied to the over-all design.

The performance characteristic of rocket fuels is usually represented in terms of the specific impulse of the propulsion system; that is, the impulse which a unit weight of fuel imparts to the rocket vehicle when it is burned. This number has the dimensions of seconds, and typical

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[1] R. F. Rose, Jet Propulsion Laboratory, private communication.

rocket propellants have specific impulses ranging between 200 and 300 seconds.

Structural efficiency in rocket design is highest when the minimum amount of the rocket weight is absorbed by the tank's engine and other elements of the structure. These elements added together are called the dry weight of the rocket. The total weight of the rocket is, then, dry weight plus fuel weight. For any given total rocket weight, higher efficiency of design corresponds to a higher fraction of the total represented by fuel and, consequently, a smaller of the total represented by the dry weight. In measuring the efficiency of a rocket-propulsion system, the weight of the guidance system and payload are usually omitted, since ordinarily these weights are established as fixed quantities as far as the rocket design engineer is concerned.

The efficiency of rocket design is typically represented by the percentage of the total weight represented by fuel. Typical values for this number run from 75 per cent to 95 per cent. Thus, for the least efficient rockets in this range, only 75 per cent of its weight is available for fuel, 25 per cent being used up by metal parts. At the other extreme, the structural efficiency has been increased to the point where only 5 per cent of the total weight need be taken up by metal parts and 95 per cent is available for fuel.

A weight saving in the total vehicle configuration can be accomplished by using multiple stages; that is, two complete propulsion units: the first to launch the vehicle and give it an initial velocity boost and the second to increase the velocity as required to achieve the range. Although multiple-stage rockets are somewhat more complex than single-stage rockets, their design and development do not appear to represent an intractable problem for a nation with limited industrial capabilities. For example, the United Arab Republic displayed a two-stage missile in a parade in the summer of 1963.[1] One year previously, they had displayed a single-stage rocket whose engine appeared to be of the same size as the one used in the first stage of the two-stage rocket. A brief analysis of this particular missile will be helpful in understanding the more general analysis we will undertake further on. The single-stage UAR missile is reported to have a length of 36 feet.[2] Judging from the photos of this rocket, the tank volume available for propellants is a little less than 200 cubic feet. If this fuel is acid and kerosene as reported, the total fuel weight is more than 15,000 pounds. The specific impulse of this fuel combination is 230 seconds. The reported range for the UAR missile is 360 miles. Fifteen thousand pounds of acid-kerosene propellants could launch a total deadweight of 8,600 pounds over such a range. If the structural efficiency of the missile system is represented by fuel fraction of 75 per cent (similar to German V2 and considered fairly primitive by modern design standards), then the tankage, propulsion, and

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[1]See AVIATION WEEK AND SPACE TECHNOLOGY, pp 30-31, August 5, 1963.

[2]See AVIATION WEEK AND SPACE TECHNOLOGY, p 20, July 30, 1962.

structural portion of the missile would use up 6,100 pounds of this deadweight, leaving 2,500 pounds for guidance and payload. For such a missile, the payload could consist of a second stage, which would then carry a smaller payload to a greater range (for example, the 650-mile range claimed by President Nasser).

It is reported that this missile was developed with the help of experienced rocket technologists imported from Germany. If true, this report indicates still another way in which an underdeveloped country can gain the ability to produce a rocket weapon; that is, by the importation of experience. It was pointed out earlier that a typical oxidizer for solid propellants, ammonium perchlorate, could be purchased on the world market. It is clear that machine tools can be so purchased. The example of the UAR development indicates that experienced personnel can also be purchased by countries which are limited in their self-developed technical expertise.

In order to estimate possible sizes for simple missiles which might be developed by countries only partially industrialized, a rough design analysis has been made of a conceptual two-stage missile capable of carrying a 1,000-pound payload over a 1,500-nautical-mile range. It was assumed that both stages in the missile were designed with the same structural efficiency and that the specific impulse of the engine for the second stage was approximately 50 seconds higher than that of the first stage (this assumption is based on the fact that propulsion systems are somewhat more efficient when operating at high altitudes, and this difference is about 50 seconds for propellant combinations in the range of interest). For the particular design assumptions used in this study, the resulting first stage alone would have a range of 250 miles with a payload ranging from 2,000 to 4,000 pounds.

A range of propellant-specific-impulse values was considered in this study, together with a range in structural-efficiency figures. The results of the calculation show a total weight of the resulting two-stage rocket vehicle. These results are shown in the accompanying figure, where the per cent of the stage weight used by fuel is shown plotted against the assumed specific impulse for three different total weights. Information on this figure indicates the type of propellants which would give various values of specific impulse to the first stage, ranging from the low-specific-impulse liquid monopropellants with a lower limit of 150 seconds up to what are now termed the high-energy liquid propellants, with specific-impulse values of 300 seconds and above. Corresponding typical solid-propellant formulations are also indicated.[1] As mentioned earlier, ammonium nitrate and rubber might be a typical formulation for an early version of a solid-propellant rocket, and acid and kerosene for liquid-propellant rockets.

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[1]Propellant data are taken from SPACE HANDBOOK: ASTRONAUTICS AND ITS APPLICATIONS, Staff Report of the Select Committee on Aeronautics and Space Exploration, United States Government Printing Office, Washington, D. C. 1959.

Typical examples of actual structural-efficiency figures are also shown in the figure. For instance, the Viking, an early U.S. liquid-propelled research rocket, weighing about 15,000 pounds, carried between 79 and 84 per cent fuel, depending on the specific vehicle and payload.

A number of military missile systems are employed in slightly modified configurations as boosters for satellite launching vehicles. Some data on these rocket systems are available in the open literature[1] and are used in the accompanying table. These data indicate the structural efficiency which can be achieved in large modern missiles. The numbers show not only an improvement in structural efficiency with time (as a result of experience in the design of missile systems) but also a tendency for larger systems to achieve more structural efficiency.

To conclude our example, consider a conservative early design having approximately 80 to 85 per cent structural efficiency with specific impulse in the range of 200 to 230 seconds, falling within the shaded area on the figure. It can be seen that a wide range of total weights is implied by these design assumptions, from about 40,000 pounds for the greatest efficiency and highest performance propellants in the range to about 300,000 pounds for the lowest efficiency and minimum-energy propellants. These weight values are

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[1]HANDBOOK OF ASTRONAUTICAL ENGINEERING, edited by H. H. Koelle, McGraw-Hill, New York, 1961.

not unusual. United States IRBM's such as Thor and Jupiter have a total weight of the order of 100,000 pounds. Intercontinental-ballistic-missile weights are in the order of 200,000 pounds and higher,[1] and weights of first-stage boosters used for space launches have ranged from 60,000 pounds to 260,000 pounds, as shown in the table.

IV. GUIDANCE

A. Unguided Rockets

Considerable experience has been acquired in the behavior of unguided rockets, both liquid and solid propelled. Most of this experience comes from sounding rocket programs in the United States and elsewhere. The initial launching of such rockets is usually controlled by rails or launching towers or some other simple mechanical device. The flight direction thereafter is controlled by fixed aerodynamic fins, and the control forces may be augmented in some cases by spinning the complete rocket.

The best control over the impact point for an unguided sounding rocket can be achieved when good information is available on wind, on the drag characteristics of the rocket vehicle, and on the burning characteristics of the propulsion system. With rough information on the predicted burning time of the engine and the drag of the complete configuration, but good information on winds, approximately 99 per cent of all rockets fired would be expected to fall within an ellipse

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[1]SPACE HANDBOOK, loc. cit.

surrounding the target, which measures about 20 per cent of the range in the direction along the range and at 10 per cent of the range across this direction. However, if good information on motor and drag characteristics is also available, the size of the ellipse containing 99 per cent of the impacts might be cut in half.

One manufacturer of solid-propellant sounding rockets felt that, with long study and ample testing of particular configurations, requiring about 10 or 20 flight tests, this dispersion ellipse could be cut by more than half again, still without the addition of any guidance systems.[1]

B. Radio Guidance

If electronic countermeasures (ECM) do not present a threat, radio-guidance systems offer a simple, reliable method of increasing the accuracy of a missile. The fundamental task of a radio system is to control the total velocity of the missile. This is done by tracking the missile with radar, computing its speed on the basis of the Doppler frequency shift measured by the radar system, and sending a radio command to cease burning when the (predetermined) desired speed has been reached. For liquid-propulsion systems, shutdown can be accomplished by simple valve operation. For solid-propellant rockets, the shutdown is usually more spectacular. Fracturing the rocket-engine

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[1] J. D. McKenney, Aerolab Development Corp., Pasadena, California, private communication.

case with a prepositioned explosive charge is one way to terminate burning, since most solid propellants will not burn unless they are pressurized. Another way is to have already in place a set of nozzles pointing forward, located around the forward end of the case but sealed during the thrust portion of the flight. On command, the seals are fractured by explosive charges, exhaust gases are discharged through the forward-pointing nozzles which are so designed as to more than cancel the thrust of the regular nozzle at the rear of the chamber.

If either of these techniques is employed to shut down a solid-propellant engine, it is usually necessary to detach the payload from the engine at about the same time thrust is terminated; otherwise, the payload may suffer an unacceptable mechanical shock or be slowed down so much that it cannot reach its target.

This comparatively simple radio technique for velocity control can reduce the longitudinal dimension of the dispersion ellipse by a factor of ten below the dimension for a rocket with uncontrolled thrust termination.

Simple radio guidance can also improve azimuth (cross-range) control and further improve range accuracy by establishing continuous elevation-angle control. For example, a military type of radar, such as might be used for aircraft tracking and anti-aircraft fire control, could be used to provide azimuth and elevation steering-command information which could be used to compute proper radio commands to steer the rocket. These commands would then provide continuous correction of the rocket's course, either cross-range or down-range. Even rather ordinary types of radars used in this manner would result in a dispersion ellipse (as described earlier) which would measure only about one-tenth of a per cent of the range in both the cross-range and down-range directions. There is no particular requirement for special materials or special precision techniques to gain this degree of accuracy, although more advanced radar, typical of the development in advanced industrial countries, might be able to improve this steering accuracy by a factor of ten.

Radio steering accuracy can be improved by using an array of radio antennas spaced several yards, or perhaps several miles, apart. This is particularly advantageous when the launch site is fixed. Such multiple-antenna systems, using the interferometer principle or timed pulses like those used in LORAN navigation, give improved control over azimuth and elevation guidance. Sucy systems would not require large industrial bases, but they would involve more electronic theory and design sophistication than is applied in the operation of a single aircraft tracking radar.

C. Inertial Guidance

As indicated earlier, radio-guidance systems are subject to interference by electronic countermeasures, so that a nation facing an adversary with sophisticated defenses would naturally wish to avoid such a vulnerable guidance system. Modern military missiles in the

United States are now designed on the basis of inertial guidance. Descriptions of theory and design procedures for inertial-guidance systems are available from a number of open sources.[1]

Actually, an ordinary aircraft autopilot is the simplest form of inertial-guidance system. The principal limitation in most commercially available autopilots is the drift rate of the gyroscopes. This drift rate results in a cumulative error in steering. If gyroscopes from typical commercial aircraft autopilots were used in the missile environment, this drift would result in a steering error whose standard deviation might increase at the rate of one degree per minute. With the best grade of gyroscopes available for commercial autopilot application, the standard deviation of drift rate might get as low as a quarter of a degree per minute. Since the powered portion of the flight of an IRBM lasts on the order of one or two minutes, the resulting standard deviation would be between one-half and two degrees in azimuth offset at the targets. The corresponding cross-range

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[1] "Inertial Guidance," Rigley, et al, Institute of the Aeronautical Sciences, January, 1957;

INERTIAL GUIDANCE, G. Pitman, Wiley & Sons, New York, 1962;

GUIDANCE AND CONTROL OF AEROSPACE VEHICLES, C. T. Leondez, et al, McGraw-Hill Book Company, 1963;

"Inertial Navigation: Out of the Laboratory into Missile Systems," (Part I), P. J. Klass, AVIATION WEEK, Vol. 64:32-35, January 2, 1956

"Old Idea Opens Door to Inertial Guidance," (Part II), P. J. Klass, AVIATION WEEK, Vol. 64:42-43+, January 9, 1956

"Component Design Challenges Industry," (Part III), P. J. Klass, AVIATION WEEK, Vol. 64:94-99+, January 16, 1956

"Hybrid Systems Ease Design Problems," (PART IV), P. J. Klass, AVIATION WEEK, Vol. 64:76-77+, January 23, 1956 dimension of the dispersion ellipse which we described previously is 3 to 12 per cent of the range.

Inertial-guidance systems, which are more advanced than the autopilot, involve the use of an inertial platform and more refined gyroscopes. The development of inertial platforms requires laboratory testing. The required laboratory is similar to a typical optics lab; that is, it requires smooth, steady, benched areas well anchored to a stable foundation and a clean environment, probably with a filtered air supply, etc. It would be necessary to furnish this lab with a certain amount of special equipment which would require approximately one year to develop in an instrument shop typical of those in most U.S. technical colleges.

More accurate gyros can be built using the flotation technique, which can be accomplished in a simple and effective way by using the elements from a standard,mechanically supported gyro, placing them in a container and floating them in a fluid of proper density.

A comparison of the difficulties required for the development of radio guidance versus inertial guidance indicates that radio guidance offers by far the simplest technique for a first-generation missile. This conclusion is verified by the experience of American missile developers. For most missile families, radio guidance preceded the use of inertial-guidance systems. Thus, as pointed out earlier, unless electronic countermeasures posed a serious threat, a nation setting forth on its first venture into military missile development would probably select the radio-guidance system.

D. Flight Testing

In the development of either radio or inertial guidance, some flight testing is required. Most of the "debugging" tests can be accomplished with fighter aircraft rather than with missiles. However, eventually missile flight tests must be undertaken, just as for the complete evaluation of an unguided configuration. Specialists in the field estimate that a minimum of 10 flight tests would be required to prove out the system and discover the need for any design modifications. More probably, 20 to 30 flight tests would be required, with a flight-test schedule lasting one to two years.

These flight tests need not be carried out at maximum range or maximum altitude, since only during the powered portion of flight are the guidance forces applied, at least for a missile of the order of 1,000-kilometers range or more. Thus, if it were desired to hide such flight tests from observation by distant radars, the firing angle could be depressed to decrease both range and altitude while still carrying out a complete test of the guidance system.

V. DEVELOPMENT SCHEDULES

At many points in the preceding sections we have emphasized the importance of time as being more critical than the availability of a large industrial base. The amount of time required is very difficult to estimate. Although data are available on the development history of some missile systems, each system represents a special case, and it is hard to justify the establishment of any general rules.

Furthermore, cases yielding these data, i.e., the German development of the V2 and the U.S. development of its missile family, are those in which development programs were based on a long history of preliminary work with various rocket components. None of these developments really started from scratch in an effort to produce a large military missile. Nevertheless, such data are all that are available, so with appropriate reservations we apply it to the present analysis.

The development of the German V2 weapon (originally called the A-4) grew out of previous work on smaller rocket systems (the A-1, A-2, A-3, and A-5). It was probably in the time period of 1936 to 1937 that serious work on a long-range (200-mile) missile began by the Peenenunde group.[1] Appropriations authorized by General Kesselring from the Air Ministry came through in mid-1936 which permitted the establishment of the Peenenunde station, and at this time the V2 was in the planning stage. Hitler visited the rocket test stand at Kummersdorf in March of 1939 and watched the test firing of a large engine. The first test firings of the V2 occurred on June 13 of 1942. The first firing in action was in September of 1944. This means a time period of approximately eight years between the initial planning phase and the initial operational phase and also shows a flight-test schedule occupying the last two years.

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[1] ROCKETS, MISSILES, AND SPACE TRAVEL, Willy Ley, The Viking Press, New York, 1957.

The development of the V2 was based on the prior experience of its development engineers. Nevertheless, it was the largest rocket which had ever been built, and its motor was the largest engine which had ever been fired. It represented a significant advance in rocket technology which is in some ways comparable to the advance an under-developed nation might have to make in starting with published information from other countries (perhaps with the help of imported material, tools, and even technologists) and attempting to develop a large military rocket system.

A somewhat different example is the development history of the Vanguard satellite launching vehicle. This was a three-stage rocket vehicle with a total weight of about 22,000 pounds developed for the specific purpose of launching scientific satellites during and after the International Geophysical Year. In its development, it made full use of all available technology which had grown up in a well-developed, guided-missile industry. The first-stage engine was a modification of an existing engine similar to the one which had powered the Viking sounding rockets.

The development program was initiated in 1955. In March of 1958, it accomplished its first successful satellite launch. The second success occurred in February, 1959, and the third success in September, 1959. If the Vanguard had been developed as a military system, it might have been considered in operational status in 1960--five years after the initiation of the project and, again, with a two-year flight-test period.

Development time depends not only on technological problems but also on the degree of effort which a government wishes to assign to the project. If a number of different concepts can be tested out in parallel, then the total time for the required trial-and-error can be considerably cut down. But even with a crash program it is difficult to see how a country inexperienced in missile technology could develop a rocket system in a time less than the five years which was required for the Vanguard project. The eight-year period represented by the V2 schedule is probably more realistic, and a 10-year allowance would be conservative.

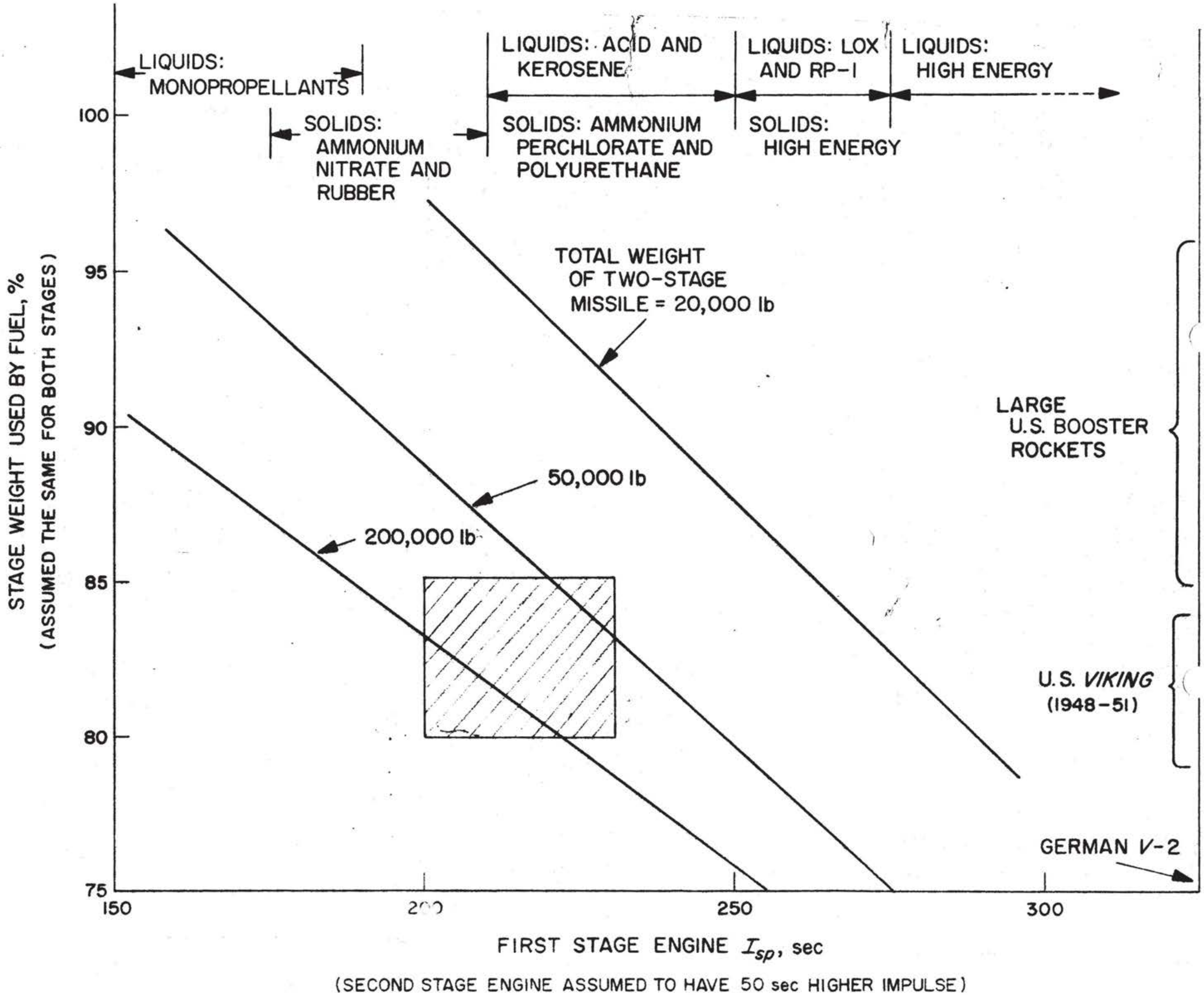
VI. CONCLUSIONS

Experience which has been accumulated in the development of modern military missile systems indicates that a nation with a modest industrial base could develop a simple strategic missile with modest accuracy capable of carrying a payload the order of 1,000 pounds over a range the order of 1,500 miles (IRBM range). It could do this using either solid- or liquid-propellant technology and might, in fact, attempt both methods in parallel.

An inertial-guidance system is more complex and time-consuming to develop than a radio system capable of the same accuracy. Thus, radio guidance would probably be chosen as the first improvement over the unguided rocket, unless other factors (such as the threat of electronic countermeasures) placed a special premium on the inertial system.

Commercially available aircraft equipment and standard military anti-aircraft radar systems could form the basis for a radio-guidance system capable of steering the rocket with an accuracy great enough to place at least 99 per cent of the warheads launched within 15 to 20 miles of the target point at maximum range. Without any guidance system but with thorough knowledge of the vehicle and motor characteristics and good wind measuring techniques, a dispersion ellipse of about 75 miles by 30 miles for 99 per cent of the rounds might be achieved.

Much of the flight testing for guidance development could be done with aircraft, and propulsion-system development could be carried out to a large extent on static test stands. Eventual flight testing of the system would require 10 to 30 flight tests, almost all of which could be done at reduced range and altitudes, if it was considered necessary to avoid detection during the flight-test phase. This flight-test program would probably occupy the last two years of a total development schedule of about 8 to 10 years.


LIQUIDS:
MONOPROPELLANTS
LIQUIDS: ACID AND
KEROSENE
LIQUIDS: LOX
AND RP-1
LIQUIDS:
HIGH ENERGY
SOLIDS:
AMMONIUM
NITRATE AND
RUBBER
SOLIDS: AMMONIUM
PERCHLORATE AND
POLYURETHANE
SOLIDS:
HIGH ENERGY
TOTAL WEIGHT
OF TWO-STAGE
MISSILE = 20,000 lb
50,000 lb
200,000 lb
LARGE
U.S. BOOSTER
ROCKETS
U.S. VIKING
(1948-51)
GERMAN V-2
STAGE WEIGHT USED BY FUEL, %
(ASSUMED THE SAME FOR BOTH STAGES)
100
95
90
85
80
75
150
200
250
300
FIRST STAGE ENGINE I_{sp}, sec
(SECOND STAGE ENGINE ASSUMED TO HAVE 50 sec HIGHER IMPULSE)

STRUCTURAL DATA ON MODERN BOOSTER ROCKETS

CONFIGURATION	First (Booster) Stage Total Weight, Loaded with Fuel (lbs)	First Stage Fuel Weight (lbs)	Fuel Fraction (%)
Juno I	62,700	53,400	85
Juno II	120,000	108,000	90
Thor-Agena A	109,000	102,000	93.5
Atlas-Agena A	265,000	253,000	95.5

3

Being held by agreement w/ NEA until after next inspection.

1/19/65

Standard Form 63*
November 1961
GSA Gen. Reg. No. 27

MEMORANDUM OF CALL

Date 1/12	Time 3:40

TO— RWK

☑ YOU WERE CALLED BY— ☐ YOU WERE VISITED BY—

Robert Black

AID- Program Coordination Staff

TELEPHONE:	Number or code 182	Extension 3595

☑ PLEASE CALL ☐ WAITING TO SEE YOU
☐ WILL CALL AGAIN ☐ WISHES AN APPOINTMENT
☐ RETURNING YOUR CALL
☐ IS REFERRED TO YOU BY:

LEFT THIS MESSAGE:

Received By—

63-106 U.S. GOVERNMENT PRINTING OFFICE : 1963 OF—696-349

M.E.
Nuclear

3a

Being held
by agreement
w/ NEA until
after next
inspection.

1/19/65

Returned to Edward Roberts
for file by HHS memo
5/31/67.

6255

3b

DEPARTMENT OF STATE
WASHINGTON

December 18, 1964

~~SECRET~~

MEMORANDUM FOR THE PRESIDENT

Subject: Preventing Nuclear Proliferation in the Near East.

Recommendation: That you authorize negotiations with Israel designed to extend IAEA safeguards to all Israeli nuclear facilities and that you approve the enclosed letter to Prime Minister Eshkol as the first step in this new approach to prevent Israel and the U.A.R. from developing or acquiring nuclear weapons.

Discussion:

1. The Pressures on Israel: The arms rivalry in the Near East has reached a dangerous stage. As U.A.R. missile technology improves, Israel seeks to develop an unmatched, economical counterdeterrent. This seems destined to lead to development of nuclear warheads for Israeli missiles purchased from France.

2. The Israeli Strategy: Prime Minister Eshkol has told us orally that Israel's nuclear activity is peaceful. Nevertheless, neither he nor Ben-Gurion has ruled out Israel's developing a nuclear weapon if the Near Eastern situation warrants. Moreover, we must remember they deliberately misled us initially about the nature of the nuclear facility at Dimona. Therefore, we must assume they intend to make their decisions on nuclear weapons without consulting us. Lower level Israeli officials speak frankly about Israel's strategy toward the U.A.R.: a) surface-to-surface missiles targetted on the Nile delta and b) a capability to bomb and release the waters behind the Aswan High Dam. Destruction of the Aswan Dam would require a nuclear warhead; bombing with high explosives could not be counted on to do the job.

~~SECRET~~

GROUP 3
Downgraded at 12 year intervals; not automatically declassified.

3. What We Can Do: Our efforts to slow down the U.A.R. sophisticated weapons program--as well as potential nuclear weapons programs in India and elsewhere--will be influenced by the example we set in dealing with Israel. The world recognizes we have compelling leverage on Israel because of our special relationships. So long as the Dimona reactor operates without publicly recognized safeguards, the credibility of our worldwide efforts to prevent proliferation is in doubt.

Israel has signed the partial Test Ban Treaty and is a member of IAEA. It is, therefore, reasonable for us to ask Israel to accept IAEA safeguards on all of its nuclear facilities. If Israel does not intend to produce a nuclear weapon, she has nothing to lose by acceding. Unilateral action by Israel to place all of its nuclear facilities under IAEA safeguards would place great international pressure on the U.A.R. and other states to follow suit.

Meanwhile we should continue to press for inspection of Dimona every six months as agreed. Enclosure No. 2 lists developments that show persuasion and secret U.S. inspection are not sufficient, however.

I think that you alone carry the weight to persuade Eshkol to take this unilateral action. For this reason I am enclosing a draft letter that you might send to him.

If he resists the suggestions contained in this letter, we could consider the graduated scale of pressures listed in Enclosure 3.

There is great urgency about this matter in view of the disturbing signals we have been getting from Israel. I think, therefore, that this is something we must come to grips with promptly. A letter along the lines of the enclosed would seem an essential initial step.

George Ball
Acting Secretary

Enclosures:

1. Proposed Letter to Prime Minister Eshkol.
2. List of Developments.
3. List of Graduated Scale of Pressures.

6255

3c

ENCLOSURE I

~~SECRET~~

PROPOSED MESSAGE TO PRIME MINISTER ESHKOL

Dear Mr. Prime Minister:

I have been thinking over our recent exchanges of messages on the inspection of Dimona. I can understand that secret inspections pose problems for you. On the other hand, failure to make such inspections on a regular basis poses a difficult problem for us and we feel compelled to continue them.

As you know, my government is unalterably opposed to any further proliferation of nuclear weapons. The partial Test Ban Treaty was a small step forward. In furtherance of our objective, our policy is to press for extension of IAEA or similar safeguards to all nuclear facilities throughout the world in those countries not now possessing nuclear weapons. We have made substantial progress thus far, and 19 countries including the United States have accepted IAEA controls over all or part of their nuclear facilities.

Action by Israel to place the Dimona reactor and all other nuclear facilities under IAEA controls, as you have already agreed to do for the Nahal Soreq reactor and for any U.S. materials or equipment transferred to Israel in connection with the U.S.-Israeli desalting program, would establish an effective ceiling beyond which the Near East arms race would not escalate. In order to protect Israel from any political injustices in the IAEA--which we by no means anticipate or even believe could occur--my government is prepared to exchange classified letters with Israel setting forth the steps that we would guarantee to take to relieve your government in the event of an injustice.

We do not see any U.A.R. nuclear capability for the foreseeable future and are convinced the U.S.S.R. will not supply Nasser with nuclear weapons. Suspicion that Israel is developing nuclear weapons, however, might stimulate Nasser to make concessions to the U.S.S.R. that could result in a Soviet nuclear support program similar to the one that existed in Cuba. Voluntary adoption of IAEA safeguards would cost Israel nothing, would clearly demonstrate Israel's peaceful intent to the whole world, would go far toward easing area tensions and abating the arms race, and would put pressure on other countries to do likewise.

I make this proposal in deadly earnest and strongly urge you give it your most serious consideration. For the next several years, Israel can rest secure in the knowledge of its military superiority over the Arabs and the steadfast assurances of U.S. support against aggression. Our military experts consider U.A.R. missiles only a psychological threat with negligible military potential. In my judgment such an initiative by Israel to adopt IAEA safeguards would be in its own interest, since it would help assure Israel's long-term security by removing the threatening shadow of nuclear war in the Near East. Israel's example would also reinforce our efforts to persuade President Nasser to limit sophisticated weapons acquisition and encourage other countries to renounce the awesome decision that automatically would make them subject to possible preemptive attack.

You may be sure that our interest in the security of your country remains unchanged. The grave responsibility which this puts upon us is an important factor in my conviction that we must leave no stone unturned in our efforts to maintain peace.

Sincerely,