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(6) THEATER CRUISE MISSILES:
CONCEPTS AND CONSIDERATIONS.

By

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(11) JUNE 1979

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EXECUTIVE SUMMARY

Military forces should derive from and support defense and foreign policy seeking to protect vital interests from threat. Worldwide interests have caused U.S. policy to focus on defense, deterrence, and detente, all in concert with our Allies.

In seeking to support NATO policies in Europe, forces must be able to respond in kind at the aggressor's chosen level of attack with some approximate equality in capabilities--a talionic balance is required. Outside NATO, in areas where U.S. and other Allied presence is diminished, a need for rapidly deployable forces exists.

Military force planning should seek to deter enemy attacks through (a) credible capabilities for militarily effective employment, (b) adequate survivability, (c) flexibility, (d) discrimination to control escalation, (e) non-provocative, retaliatory roles, and (f) retaining post-attack, reserve warfighting capabilities. By threatening to deny an enemy's achieving his objectives, clearly defensive warfighting forces demonstrate a strong deterrent. Tests of current and proposed forces against planning criteria must also address affordability, Allied perceptions, and enemy reactions.

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Theater cruise missiles seem uniquely suitable and beneficial in meeting the criteria to support defense policy. Deployed in the European theater, both ashore and afloat, they can balance an increasingly modern Soviet peripheral attack threat with effective, survivable, affordable, and controllable forces representing NATO solidarity--defense and deterrence would be enhanced, while detente would be supported. USAF ground launched and USN sea launched Tomahawk cruise missile programs could be (a) expanded to include Allied nuclear programs of cooperation and conventional cruise missile foreign military sales, (b) accelerated to increase missile production to reduce unit cost, and (c) planned to conform to arms control agreement timing, balancing acquisition of deterrent means with the need for stability.

Early procurement and 1981-82 deployment of anti-ship cruise missiles on surface combatants and submarines should be followed by augmenting land attack variants. Conventionally armed ground launched cruise missiles, followed by nuclear armed versions, could begin deployments in Europe about 1984. Allied participation, both in Europe and in other areas threatened by Soviet expansion or intervention, should be encouraged to increase defensive cohesion. Cruise missile systems, and their advantages, should be viewed as complementary to current forces, such as reloadable and retargetable tactical aircraft and more responsive and better defense penetrating ballistic missiles.

Force planning criteria important to the support of policy and advantageous characteristic of cruise missiles include:

CRITERIA	CRUISE MISSILE CHARACTERISTICS
Survivability	Low cross section and altitude, high speed, mobility, hardening, dispersal, concealment.
Flexibility	Variety of launchers, plans, range, warheads.
Effectiveness	Nuclear hard target, conventional submunitions.
Stability	Long time of flight, second strike, survivable; no incentive to preempt.
Solidarity	Basing, sales, programs of cooperation, dual capable link, strategic coupling.
Affordability	Relatively cheap - expensive to defense.
Credibility	Precise, selective use, control, low collateral damage.
Arms Control	SALT II consistent, valuable.
Balance	Theater offset to SS-20, Backfire, etc.

Three major issues concern theater cruise missiles.

- First, arms control in the military sphere of detente involves ceilings on cruise missiles. SALT II limits long-range cruise missiles, but with ambiguities concerning non-circumvention, verification, and ill-defined post-1981 Treaty terms for long-range ground and sea

launched cruise missiles. MBFR could set implicit missile launcher ceilings in part of Western Europe. SALT III most likely will address long-range theater systems, seeking to establish ceilings on U.S., Allied, and Soviet non-strategic weapons.

- Second, the procurement of cruise missiles will be based, in large part, on the relative cost-effectiveness of Air Force GLCM, Navy SLCM, dual-capable aircraft, and other missiles, e.g., Pershing II, and a new MRBM.
- Third, participation in basing and ownership will involve complex assessment of Allied perceptions, likely Soviet reactions, and weapons system value.

There appear to be several interim actions in the areas of procurement, participation, and publicity associated with the major issues, including:

- Putting a floor under GLCM procurement funds.
- Reinstating SLCM land attack purchase.
- Increasing the number and type of Navy platforms planned for SLCM.
- Confirming GLCM basing details with NATO Allies.
- Negotiating sales of non-nuclear cruise missile hardware.
- Establishing nuclear programs of cooperation with NATO Allies.
- Advertising U.S. intent to sell cruise missiles and to base USAF GLCM in Europe.

- Publicizing the non-provocative nature of these survivable, effective, and non-first strike weapons.

- Demonstrating commitment to a stable balance of long-range theater systems in support of U.S. and Allied policies and vital interests.

Theater cruise missiles can provide significant support of U.S. policies of defense, deterrence, and detente, thereby protecting vital U.S. interests. Additionally, they offer substantive advantage to NATO national forces and other Allies and friendly nations through demonstrated U.S. commitment and Allied participation. National goals of peace, security, and stability can thus be buttressed through military strength and political solidarity.

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CHAPTER I

INTRODUCTION

> We are building that new foundation from a position of national strength--the strength of our own defenses, of our friendship with other nations, and of our oldest ideals. America's military power is a major force for security and stability in the world. We must maintain our strategic capability and continue the progress of the last two years with our NATO allies, with whom we have increased our readiness, modernized our equipment, and strengthened our defense forces in Europe.
>
> President Jimmy Carter
> State of the Union
> January 23, 1979

National policy forms the basis for military power, including the forces and weapons systems projected for the future. This paper examines national values, vital interests, defense policy, and derivative forces equipped with theater cruise missiles in support of national and alliance goals.

Power Derives From Purpose

If, as Clausewitz declared, "war is merely the continuation of policy by other means," the means of military power should derive from national purpose. In a practical sense, this theoretical correlation of forces to policy is difficult. First, policy suggesting weapons systems and force deployments involves long lead times for research, development, test, procurement, training, and introduction into units. Second, the inertia of having certain forces in being tends to restrict the choices

among policy options to a practical few which are usually evolutionary in tone. Third, dramatic policy shifts which would necessitate massive force changes are unlikely in a free and open democratic society, particularly in view of stiff competition for scarce resources. In essence, evolving national policy, based on a few vital interests, can generally be best met with doctrinal shifts, coalition planning, evolving forces, and weapons having an inherent flexibility to meet those policy shifts in an operational sense. At the same time, external factors which tend to drive national interests and policy must be acknowledged. Changes in the threat, alliances, and domestic priorities, which might not change overall defense policy to a large degree, may result in more significant cost changes in defense programs. In any event, the utility of military means should be evaluated in terms of how well the means support the policy.

> All this suggests that in the sizing and shaping of our military forces we should give added emphasis and more explicit attention to the national-level purposes and security needs that these forces are to serve. In relation to the pulls and pressures internal to the military establishment, the higher goals that should guide and shape defense programs more often appear to be the results of military programs than their determinants.
>
> If power is indeed to be correlated with purpose, an approach that naturally commends itself is an analytic progression that moves from national values exposed to outside international threat to national interests requiring security protection, to security policies designed to safeg ard such interests, and finally to military forces best suited by role and posture to carry out such policies, safeguard such interests, and protect such national values.[1]

Arguments against such a progression from national values to military forces and their usefulness involve two basic rationales - the analytic progression is both too complex and too simple. When dealing with vague values, often conflicting interests, uncertain threats, changing or poorly enunciated policies, ambiguous strategies, and a host of unknowns and unknowables, it is too hard to derive military means to support policy. At the same time, since national values and interests are so commonly understood, it is almost trivial to postulate defense strategy and forces, particularly since affordability is probably the most central defense issue. While accepting the validity of certain counterarguments, it is still useful to exercise this analytic method, which is similar to that required of the Secretary of Defense, in consultation with the Secretary of State, by law, i.e., Section 812 of the Fiscal Year 1976 Department of Defense Authorization Act. The preparation and presentation of "a written annual report on the foreign policy and military force structure" and their relationship and justification provides a correlation of power with purpose.

The reverse view postulated by General Goodpaster, higher goals resulting from military programs, seems unfortunately close to the mark in our highly technological, free enterprise environment. Innovative hardware is often pictured as a solution to perceived shortcomings in tactical capabilities, whereas the more proper view might address why, rather than how, the hardware

should be procured. Putting purpose first in statements of military "requirements" gives focus to the usefulness of competing alternatives in achieving national goals. Therefore, the model he provides presents a logical progression from broad and historic national values, vital interests requiring defense against threats, and security policies and strategy to orient the means of military force to that defense. In essence, values define national interests; national security policy demands that we defend those interests; defense strategy defines how we defend; and defense programs and forces provide the means of defense.

National Values

National values include broad concepts with which most Americans can easily agree. The classic formulation of these values hews back to our reason for national existence as expressed in the 18th century:

> ...to form a more perfect Union, establish Justice, insure domestic Tranquility, provide for the Common Defense, promote the General Welfare, and secure the Blessings of Liberty..."[2]

> The Constitution makes providing for the common defense the first duty of government, and quite property so. Without a sufficient defense, we are unlikely to maintain the other conditions necessary to the enhancement of our values.[3]

As these general concepts are translated into more and more specific "how to" language, more divergent views are generated. Alternative security policies and defense program options are proposed by a wide variety of responsible public and private

organizations and individuals, all seeking to support essentially agreed upon national interests, but in different ways. While recognizing that other choices and paths exists for policies, programs, and budgets, the directions of the present Administration provide a framework in which to assess national security interests, policies, and forces, particularly theater cruise missiles* and their capabilities to support national goals and safeguard national interests.

External threats to U.S. interests of world-wide security, peace, and economic growth and stability are both severe and widespread. In particular, the non-strategic military implications of defense, deterrence, and detente policies constitute a difficult and somewhat neglected set of strategy and force concerns. Potential confrontations in theaters of operation present an array of problems indicating a need for rapidly deployable and employable military forces having significant long range firepower. As a weapons system complementing other forces in being, cruise missiles fulfill that need and assist in carrying out security policies to safeguard national interests.

---

* Cruise missiles, described in more detail in Appendix A are small, low flying, subsonic weapons with high accuracy. Cruise missiles can be long-range strategic, e.g., Air Launched Cruise Missile (ALCM), or short range; nuclear or conventionally armed; fired from aircraft, ship, submarine, or ground launchers.

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CHAPTER II

INTERESTS, POLICIES, AND THREATS

> To serve the interests of every American, our foreign policy has three major goals. Our first and prime concern is and will remain the security of our country. Security is based on our national will and on the strength of our armed forces...Security also comes through the strength of our alliances...Security can also be enhanced by agreements with potential adversaries which reduce the threat of nuclear disaster while maintaining our own relative strategic capability.
>
> President Jimmy Carter
> State of the Union
> January 19, 1978

Interests

This critical prime concern for security is interwoven into the other two national interests of peace and economic growth and stability, as well as remaining a primarily military oriented goal in its own right. As the prime concern, security is similarly affected by other factors:

> ...we understand very well that life, liberty, and the pursuit of happiness require much more than freedom from external military threats. We are not secure as a nation--in fact, we cannot even be secure militarily--if our economy is under repeated attack from inflation, recession, and shortages of energy or essential raw materials. We are not secure as a nation if we are increasingly an island of democracy surrounded by authoritarian states and cut off from external markets and cultural exchanges. And surely, we are not secure as a nation if we lose confidence in our ability to cooperate among ourselves in the solution of our foreign and domestic problems.[1]

The external military threats, increasing through the Soviet Union's dedication of a significant portion of its Gross National Product to military forces and hardware, include a wide variety of potential conflicts, not strictly military. Client states, revolutionary movements, non-aligned diplomatic and economic pressure groups and a generally unsettled, but interdependent world create a myriad of situations antithetical to U.S. national interests. With Soviet military might presenting the clearest direct threat to the United States, this Administration's policy sets forth four fundamental security responsibilities:

- To provide for our nation's strength and safety.
- To stand by our allies and friends.
- To support national independence and integrity.
- To work diligently for peace.

> ...If we are to meet our responsibilities, we must continue to maintain the military forces we need for our defense and to contribute to the defense of our allies...There must be no doubt that the people of the United States are fully prepared to meet its commitments, and to back up those commitments with military strength.[2]

As the ultimate resort, should alternative political, diplomatic, and economic efforts fail to achieve the nation's purpose, military power is central to safeguarding the nation's vital interests. In striving for adequate military strength, appropriate balance with competing national priorities and efficiency in defense efforts must be maintained. In addition

to direct procurement of more and better military capabilities, alternative ways of counterbalancing perceived threats and meeting national responsibilities must be sought. A wide range of allied and friendly nations tend to offset the effects of tension brought by the main potential adversary power and aligned nations, as well as providing a partial counterbalance to third world economic and political pressures. In a highly interdependent world, the United States role lies somewhere in the middle ground between isolation, which is infeasible, and total involvement. Secretary Brown has noted the manner of acting in such a middle role, as:

> "U.S. involvement and leadership...mean that we have a large stake in the peaceful settlement of disputes and world stability...But where our interests are at stake...it is to our advantage to act early and positively.[3]

The national interests clearly extend beyond securing national borders and protecting U.S. citizens abroad and U.S. ships at sea. Trade, economic, and political ties are critical to the nation.

> As President Carter has emphasized on a number of occasions. Western Europe is of vital interest to the United States. Outside the United States and Canada, it constitutes the greatest aggregation of economic and democratic strength in the world...we must prevent the hostile domination of this region, and we must help bring the talents and resources of Europe both for its own defense and to the creating of more peaceful and stable world conditions.[4]

Secretary Brown goes on, in greater detail, to explain U.S. vital interests and the importance of Asia, especially Japan and

South Korea, the Middle East, Africa, and Latin and South America, the last being of special importance.[5]

> It remains the case that our well being as a nation and our character as a people depend on peace, justice, and order as well as military strength To survive, to prosper, to perserve our traditions, we need political as well as military allies, trading partners, access to raw materials and supplies of energy..."[6]

The interests of freedom, peace, and stability as international goals of U.S. national policy are well put by General Goodpaster:

> We would find economic, moral, and security satisfaction in seeing other nations free, prospering and nonaggressive in their outward policy... We would be prepared, in principle, to assist other nations to maintain their sovereignty and freedom from outside coercion, limiting ourselves in the actual burdens we could assume according to considerations of priority and feasibility.
>
> ...U.S. military power--together with a widely shared awareness of that power--remains essential. It is a major determinant of U.S. and world ability to sustain peace and security, with stability and national freedom. It helps to deter or constrain international resort to violence and to resolve quarrels and disputes when they occur."[7]

The search for peace, security, stability, economic growth, and freedom for the United States and friendly nations applies all elements of national power toward these interests. Diplomatic, socio-economic, and scientific-technical pressures are often indirect but effective in staving off threats to the national interests for worldwide stability and cooperation. However, they would lose much of their effectiveness if the

background presence of significant military power were less clear. Of the available means to protect U.S. interests, the policies for military force acquisition and employment form a foundation underlying the strength of the nation to enforce its political goals.

Security Policy

There is an apparent dilemma in basing goals of world-wide peace on security policies involving the use of force. Having "too much" military force might indicate an inherent policy of expansion through the use of available force while having "just enough" military force could provide peace through strength. Inadequate force could not support peaceful policies in a meaningful sense. Security policy therefore must address sizing issues of how much is enough, how much is too much, and how much is insufficient, all in consideration of the policy goals and national interests, as well as threats to those interests. The policy paths to security for those interests involve defense, deterrence, and detente.[8]

Defense, as the planned or actual use of military force to protect national interests, can be subsumed into deterrence policy if the assumption is made that deterrence relies, in large part, on the capability to wage war. By explicitly linking military effectiveness to deterrence, one acknowledges the view of deterrence as the perceived product of capability and credibility. Other factors contributing to deterrence (e.g., adversary perceptions, allied participation, commitment to use) could then

be sub-categorized under the dominant categories of capability, credibility, and cooperation, or detente.

U.S. detente policy seeks to support national interests by aiding potential adversaries to have vested interests parallel with U.S. interests. For example, by creating economic and trade incentives, economic growth and stability in an interdependent world become common interests to a wide variety of political and economic entities. Cooperation, in the face of competition, has been a method of dealing with, in particular, the Soviet Union over the last several years. Perhaps the clearest area of military-associated detente involves arms control. As Secretary Brown has stated; "we should lose no opportunity to increase international stability and reduce military competition through equitable and verifiable arms control agreements."[9] In addition to attempting to introduce greater stability into the nuclear balance, arms control generally seeks to reduce the risks and consequences of wars, to build mutual confidence and trust, and to lower the costs of defense programs, contributing to detente.

Deterrence, as the other policy path to security of national interests, can also be considered as a strategy and force structuring guide. How deterrence works involves discussion of philosophical deterrent mechanisms beyond the scope needed to describe a deterrent policy and strategy. Perhaps deterrence can best be viewed as the policy of preventing an adversary from actually threatening national interests by displaying sufficient

forces and the will to use those forces so as to convince the adversary that the risks or costs of achieving an objective are excessive. Deterrence, as a policy, has a much more complex meaning than this simple statement; it also takes on a variety of strategies to support alternative views of deterrent mechanisms.

The security policies of defense, deterrence, and detente seek to protect the national interests of security, peace, and economic growth and stability against diverse threats. It is recognized that Soviet strategic superiority might constitute the gravest threat to vital U.S. interests and that economic pressures of energy crises might claim more immediate attention. However, more likely military threats, perhaps because they tend not to be in the limelight, seem deserving of addressal.

Threat to the Theater

Threat assessment, seeking to expose intentions by measuring capabilities, is necessarily uncertain in practice. In lieu of presenting detailed background data and analyses, the hypothesis of an imprecisely defined theater-level threat by the Soviet Union is based on the following:

--Wars of national liberation and violently disruptive third world events tend to serve Soviet interests, as they oppose U.S. interests, and are often supported by Soviet military means;

--Soviet domestic, economic, and dissident problems, previously explained as results of capitalist threats, might now

require direct external diversion, particularly as Soviet defense expenditures continue to consume 11-15% of the gross national product;

-- Dramatic and revolutionary military improvements in Soviet naval forces and relatively long range forces confronting NATO Europe are clearly in excess of defensive requirements;

-- Arms control efforts focused on strategic nuclear forces (SALT II) and European-abused conventional forces (MBFR)* tend to play on U.S. desires for some limiting agreement, while allowing other force increases and improvements, and;

-- Arms control efforts (as well as Anti-Satellite, nuclear test, and other negotiations) tend to convince the Western public that a detente-only policy can contain the threat.

In hypothesizing a threat to U.S. interests, it is perhaps useful to note more closely certain Soviet capabilities that are not being addressed by negotiation or U.S. countermeasures. In the strategic arena, the Soviet civil defense program connotes attempts to preserve population should an intercontinental exchange occur. With strategic offensive launchers and anti-ballistic missiles constrained equally for both sides by agreement, civil defense and reserve strategic missiles take on an ominous aspect, considering that,

> ...the original objective of U.S. arms control negotiations was to cap the strategic arms race in a position of equal numerical strength and mutual vulnerability to retaliatory countervalue destruction, and to eliminate the destabilizing possibility of a disarming threat to the strategic forces on either side.10

* See Appendix B.

In the general purpose force arena, those Soviet nuclear and conventional naval, ground, and air forces outside Central Europe are being expanded, while certain U.S. theater nuclear forces in Central Europe have been offered for reduction under MBFR. These relatively longer range systems (F-4 dual capable aircraft and Pershing surface to surface ballistic missile launchers) are part of the NATO theater nuclear forces countered by new (SS-20, BACKFIRE) and additional (nuclear capable aircraft) Soviet systems.

If SALT and MBFR adequately constrain strategic nuclear forces and conventional forces in Europe (with implicit ceilings on U.S. longer range theater nuclear forces), current Soviet advances in naval force power projection and peripheral attack nuclear systems assume greater proportions as a dominant threat to U.S. interests in Western Europe and other critical areas of the world. In a strategic stand-off, or a potential Soviet disarming capability in the worst case, the coercive military potential of evolving Soviet power projection and peripheral attack systems and forces appears to constitute a future threat as yet unopposed by any positive U.S. reaction.

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CHAPTER III

DEFENSE STRATEGY

> Generally in war, the best policy is to take a state intact; to ruin it is inferior to this... Thus, what is of supreme importance in war is to attack the enemy's strategy...next best is to disrupt his alliances...the next best is to attack his army...the worst policy is to attack cities. Attack cities only when there is no alternative."
>
> Sun Tzu

Strategic Concept

This outline of priorities does not necessarily or precisely represent any nation's current stragegy; however, it provides a concept not dissimilar from, in more modern phraseology--subversion, isolation from allies, counterforce, and countervalue only as a last resort. In the nuclear age, strategic concepts have necessarily received more frequent consideration than the strategy of less technological areas, although actual conflicts at the insurrection, local conventional war level have been common. Within the defense, deterrence, and detente policy, U.S. defense strategy has shifted from previous Administration views, although more in emphasis than subject matter. Having discarded winning, massive retaliation, and a 2½-war capability for deterrence, defense with control of escalation, conflict termination, and flexible response, U.S. strategy has been forced to recognize the loss of overwhelming military force superiority and the need for a wider array of options.[2]

Each Administration examines national policy and defense strategy in light of changing external factors and Administration goals. As the United States moved from nuclear monopoly to parity, President Truman's NSC-68 (1950), President Eisenhower's "New Look," President Kennedy's "Flexible Response,"and President Nixon's "NSSM-3: One and One-half War Strategy" focused Executive Department review efforts.[3] The current Administration's review, Presidential Review Memorandum Number 10, "Comprehensive Net Assessment and Military Force Posture Review," looked at national security objectives, strategies, and forces to reassess whether operational objectives are well related to existing realities.[4] The studies undertaken as part of the PRM-10 work, by challenging assumptions and offering alternative objectives and postures, had on occasion been mistaken for revisions to policy and strategy--as Secretary Brown went on to note, "...changes in the overall posture are almost always found to be gradual and on the margins."[5] He then summarized the trends, objectives, and force goals, including these comments: [6]

> ...the Soviet Union remains our principal national security problem--not the only one, but the biggest one...
>
> ...the Soviet Union is in the process of acquiring military power comparable to that of the United States...
>
> ...our main defense objective, in conjunction with our allies, will be the maintenance of an overall military balance with the Soviet Union at least as favorable as that which now exists...

> ...this Administration is determined to maintain the U.S. strategic deterrent...
>
> ...the United States has no desire for or plan to develop a first-strike, disarming capability against the Soviet Union...
>
> ...in an era of strategic nuclear parity, we must become more concerned than ever about a number of tactical balances... [6]

Through examination of Annual Defense Department Reports, it is clear that defense strategy, including deterrence, escalation control, conflict termination, post attack advantage, flexible and selective options, and "balanced" force capabilities, stems from the so called Schlesinger Strategy first exposed to public view in a January 1974 news conference.[7] National Security Decision Memorandum 242, 17 January 1974, promulgated nuclear policy to the Department of Defense; it resulted in publication of the Nuclear Weapons Employment Policy (more accurately, the policy plus the strategy of how to achieve those policy goals) by the Secretary of Defense on 4 April and more detailed guidance by a Joint Staff Memorandum on 15 July.[8] The Nuclear Weapons Employment Policy strategy called for deterrence and escalation control, the latter to: "...assure a U.S. position of power and influence and limit the conflict and consequences by:

- conducting selected military operations to foreclose opportunity for further aggression
- limiting the level and scope of violence to the lowest level possible consistent with U.S. interests
- holding vital enemy targets hostage to force negotiated war termination. [9]

While the strategic nuclear planning (with Allied Command Europe coordinated forces contributing to committed forces) moved toward the Single Integrated Operational Plan, U.S. nuclear commanders (CINC's LANT, PAC, EUR, and SAC) performed parallel nuclear contingency planning of Limited Nuclear Options and Regional Nuclear Options.[10] Although previous strategic concepts had allowed for some options beyond the reflex spasm of massive retaliation, the Schlesinger strategy approved by the President who had asked for a range of nuclear responses early in his Administration, called for great flexibility to deter and to defend by controlling the response.

Escalation Control

Steps on an escalation ladder range from diplomatic maneuvering through increasingly hostile actions to conventional, theater nuclear, and intercontinental/strategic nuclear wars. A principal link between the strategies of deterrence and escalation control is evident in the need for deterrent capability at each level of escalation. Within an overall policy of defense, deterrence, and detente, any substantial gap in military capability to deter at some given level could violate the escalation control strategy--inability of credibly deterring enemy action at their chosen level, the choice lies between escalating, to try to deter at a higher level, or de-escalating to attempt to deter at a lower level. The spectrum of potential conflicts to be deterred then also provides the spectrum of escalation steps subject to control. If an inadequate range of deterring capabilities exists,

both escalation control and deterrence are probably infeasible. More simply, the threat of major conventional warfare is not enough to deter a strategic nuclear threat, but it is too much as a deterrent to political coercion. Recognizing the need to deter lesser potential conflicts and threats and the need to respond in a controlled manner to appropriately manage crises without undue overraction, the more critical tests of U.S. defense strategy apply in the nuclear realm. Escalation control becomes vital at the nuclear level, as does deterrence. Without ruling out the possibility of United States first use of nuclear weapons, both strategies seem to fit within the context of retaliation or response to an attack.

The strategy of escalation control carries with it a high degree of uncertainty that retaliatory nuclear attacks can in fact be perceived as limited, constrained, selective target strikes. Given that any conflict is chaotic, the short term high damage levels inherent in detonation of even a few nuclear weapons could tend to mask the restraint which might be intended and, therefore, might tend to provoke a return strike of greater proportion -- the theoretical slippery slope leading to global holocaust which supported strategic massive retaliation and the theater trip wire. To many, more optimistic scenarios and strategies offer alternatives between nuclear suicide and preemptive surrender; in particular, the control of nuclear attack might limit violence and lead to negotiation to end the conflict.

> If the opposing strategic forces are extremely vulnerable, any use of nuclear weapons is likely to escalate...If, as is much more likely, the invulnerability of the opposing retaliatory forces increases, the controlled use of nuclear weapons takes on a different significance.
>
> The President has spoken of the need for alternatives between surrender and general nuclear war. To provide these, a capability for tactical nuclear operations would seem to be essential. Indeed, it is the most useful--perhaps the only meaningful--role for the nuclear weapons based on the Continent.[11]
>
> It is difficult to visualize a nuclear exchange that could be kept from escalating to all-out attack on cities. We would be mistaken, nonetheless, to leave a potential enemy with the prospect that, if faced with a controlled and limited attack, we would have only the options of an all-out response or no response at all. The temptation to exploit the gap would be small, but it could be real. However probable rapid escalation might be, we should have the capability to respond to such an attack in a controlled and deliberate way, even though we might not get credit for such a capability in the standard static comparisons.[12]
>
> ...many people honestly believe that once nuclear weapons are employed, regardless of how well controlled, nuclear Armageddon is inevitable. Granted, such a possibility cannot be ignored. But from a military point of view, we must provide such an option to our national leaders. Should history prove that escalation is not inevitable, such options could be the difference between nuclear holocaust and a future for those who follow us.[13]

The strategy of escalation control implies a need for survivability, flexibility, and control through discriminate militarily effective nuclear attack options. In measuring force effectiveness as it relates to escalation control, low yield, high accuracy, and low unintended collateral damage to non-targets support the strategy (note that these characteristics accrue to cruise missiles).

> The tendency for a nuclear exchange to escalate once begun might be decreased by the surgical nature of a cruise missile strike. If one accepts the basic tenets of Mutual Assured Destruction (MAD), then the logic of the preceding point is uncontestable. [14]

Mutual Assured Destruction is one of the links between the strategies of escalation control and deterrence. As President Carter noted on November 13, 1978, "...I think that the horrible surety of mutual destruction will prevent an attack being launched." Countervailing views exist:

> The Soviets never, at anytime, accepted the long-standing American Management theory that the threat of incineration of undefended populations--'mutual assured destruction'--could deter war. ...The Soviets, holding fast to the military view, give every evidence that they feel that their self-interest lies in taking nuclear war seriously. They have equipped themselves to wage it and indicate that they intend to win it. [15]

> America's nuclear strategy rests in the concept of deterrence. But it ought to be quite clear that deterrence, whatever its merits, is anything but a strategy. Deterrence...is a device for preventing war, not a guideline for the conduct of war. Now the prevention of war is the province of diplomacy, not of military strategy; the latter normally takes over precisely at the point where the former fails and the parties to a dispute resort to arms...
>
> It is the task of Soviet diplomacy to avert war; it is the task of the Soviet military to win it, speedily and with the least losses, should diplomacy fail. [16]

Even within the Administration, perhaps in a "what the President meant to say" tone, MAD has lost much of its earlier appeal:

> ...a strategy based on assured destruction alone no longer is wholly credible...Our allies, particularly in Europe, have questioned for some time whether the threat of assured destruction would be credible as a response to nuclear threats against them. [17]

Deterrence

The official conversion from views Leon Sigal attributes to "stable balancers" to "war fighter" views[18] might be farther along than critics believe. Secretary Brown stated, "Deterrence, not overbearing power, is what we seek. To have it, we must have a credible fighting capability."[19]

As noted previously, deterrence might most simply be put as the product of capability and credibility. At the risk of continuing to oversimplify, the definition of capability on which a deterrent is based is at the heart of the warfighting/MAD discussion above. An attack can be deterred by increasing the punitive cost beyond the expected gain, or by increasing the risk of not achieving the objective, or by some combination. MAD is based in large part on the unacceptable punishment view, which unfortunately glosses over the threat that our cost of inflicting punishment might also be unacceptable, so we are perhaps self-deterred even in a retaliatory mode. Objective denial, as the rationale for successful deterrence, is more closely tied to a warfighting capability. The logic lines are not quite so clean as depicted here, since, obviously, some survivable fighting capability is a desirable prerequisite to MAD. The deterrent message must be credible, plans must be available for the employment of survivable and ready forces, and the enemy must perceive the credibility and the capability which threatens to prevent his success.

> An unfortunate habit has developed of contrasting deterrence (via the threat of countervalue punishment) and warfighting (what you do if deterrence fails) strategies. This is a serious mistake. The ability to deny

> an enemy the possibility of military victory deters his initiative action perhaps more effectively than by increasing the costs he must bear, especially if these are uncertain. Against a calculating opponent under increasingly unfavorable internal pressure, it is likely that only the ability to fight well can minimize the need to fight at all. [20]

> Our main security interest will be one of denial. ...the interests of denial include denial of Soviet territorial aggrandizement, of their seizure and control of free world resources, of such an extension of their influence and control into foreign lands as would carry with it serious hazard to the United States. [21]

It should be noted that, despite the better underlying deterrent rationale of objective denial, mutual assured destruction of a countervalue nature exists as an included capability to deliver a few hundred strategic warheads on cities. As a minimum deterrent, this fact of strategic life constitutes a backdrop for an extensive objective denial deterrent. As a backdrop, it might tend to reemphasize the theater threat postulated in the last chapter.

> Assuming that each superpower can devastate his opponent's civilian assets at any time before and after the start of war and that, even in extreme circumstances, communist leaders have no desire to preside over the devastated world even if they could, then the dominant potential threat to the NATO countries is a Soviet discriminate, low-collateral-damage disarming strike against CONUS-based strategic forces and theater tactical air forces with the aim of creating a <u>critical imbalance</u> in post-attack military power and a coercive ability to terminate war on favorable terms. [22]

If one accepts the reports of increasing U.S. ICBM vulnerability to increasingly accurate Soviet ICBMs, the vulnerability of U.S. bomber bases to pin-down attacks by new and additional Soviet SLBMs and the increased Soviet emphasis on civil defense

to protect population, it might well support an increased likelihood of Soviet peripheral action, and not just in Europe. Whether a strategic disarming attempt is made (with attempts to reduce Soviet costs through city evacuation and factory hardening) or a strategic confrontation results in a stand-off, U.S. counter-value capabilities to inflict "unacceptable damage" become highly questionable. MAD (or one sided destruction) is unrealistic, counterproductive in fueling Soviet civil defense emphases, and basically self-deterring. Deterrent strategy concentrating on objective denial through a warfighting capability recognizes that nuclear weapons are available and might be used, that nuclear use has the potential for control, that negotiation for war termination is feasible, and that both deterrence and escalation control strategies can function across a wide spectrum of potential conflicts.

CHAPTER IV

THEATER POLICY AND STRATEGY

> Achieving our political goals depends on a credible defense and deterrent. The United States supports the existing /NATO/ strategy of flexible response and forward defense. We will continue to provide our share of the powerful forces adequate to fulfill this strategy. We will maintain an effective strategic deterrent, we will keep diverse and modern theater nuclear forces in Europe, and we will maintain and improve conventional forces based there.
>
> President Jimmy Carter
> To The Conference of NATO Countries
> London, 10 May 1977

> The United States has a long-standing commitment to do our share to ensure that NATO has the capabilities -- nuclear as well as non-nuclear -- to maintain the independence and territorial integrity of Western Europe. ... In addition to Europe, there are a number of other areas around the world in which there are delicate or even potentially explosive situations. The Middle East, the Persian Gulf, and Korea are three examples of areas where the United States and its allies have vital interests. [1]

The U.S. commitment to Western Europe, the NATO Alliance, and broader world interests has existed for over thirty years. During that period, the U.S. nuclear umbrella has been present in various forms of strategy evolving as external threats and alliance desires shifted. For the most part, NATO strategy has been driven by United States concepts and other-than-European strategy has been almost purely and unilaterally U.S. derived. Despite some clear differences between strategy applicable to

Europe and strategy oriented toward the rest of the world, U.S. policies, general strategy, and forces need to accommodate a set of flexible but useable guidelines adaptable to protecting basic U.S. interests.

Nuclear Umbrella

Protection of worldwide U.S. interests involves coordination of U.S. interests, policies, and strategy with those of allies and friendly nations. In particular, U.S. desires to limit the proliferation of nuclear weapons maintains the need to provide U.S. nuclear guarantees to friendly nations. Initially, the nuclear umbrella consisted of U.S. strategic forces (the few bombs available in the late 1940's), later augmented by forward based missiles. This forward basing, necessary due to early missile range limitations, was a symbol of U.S. resolve which was highly visible to allies. As longer range intercontinental and submarine launched ballistic missiles, as well as shorter range "tactical" nuclear means, evolved and were deployed, the intermediate range missiles were retired. The resultant separation of nuclear weapons systems into strategic and tactical realms was accompanied by U.S. promises that, if tactical systems were used in the theater, strategic systems would likely be coupled to such use if escalation were "needed." This artificial categorization of strategic nuclear weapons (some with yields of a few tens of kilotons) and tactical systems (a few with megaton yields) was generally based on delivery

system range capabilities and intended purpose (strategic massive retaliation or theater trip wire).

Shifts in relative force balances, basic policies, and resultant strategies have somewhat redefined nuclear forces, although ambiguities remain. Theater nuclear forces (TNF), both forward based and deployable for use in theaters of operation, are oriented to support U.S. and allied strategy in conjunction with strategic nuclear and conventional forces, with emphasis on deterring the Soviet threat to the European theater.[2]

NATO Strategic Concept

Although peripheral Soviet threats, discussed in Chapter III, are important the natural focus is on Europe. This necessitates an examination of official NATO strategy. The strategic concept adopted in 1967 reflects concerns that a range of defense options should be provided and that extensive territorial loss should be avoided; the resulting strategy centers on deterrence, forward defense, and deliberate escalatory flexible response.

> ...The United States fully supports the NATO strategy of flexible response and forward defense, and remains committed to the continued overseas deployment and modernization of its theater nuclear forces.
>
> That commitment is not in question. But whether current deployments and programs are adequate in light of Soviet capabilities has become increasingly the subject of debate both here and in Western Europe. [3]

Similarly, broader world interests are suggested for U.S. involvement:

> Our friends in Asia must also be supported by the U.S. nuclear guarantee. It remains the firm policy of the United States to maintain our nuclear contribution to the mix. [4]

Deterrence, defense, and detente, the basic U.S. policies, are added to in the NATO list by solidarity, a critical aspect of alliance or coalition politics.[5] The nature of alliances, in which consensus only follows time-consuming compromises, requires solidarity in planning and decision. The process among many of the sovereign states unfortunately creates internal charges of bureaucratic delay, watered down language, and selfish interests. Of the alternatives open to a group of relatively free and democratic states facing a more or less cohesive Warsaw Pact, none are any more attractive than the NATO alliance, despite the often valid criticisms. There are, in fact, some benefits which accrue due to such faults -- for example, by providing ambiguous language regarding basic strategy, the alliance allows each member nation (and potential enemies) the luxury of interpreting the concepts according to national biases. The deterrent value of ambiguity and uncertainty should not be underestimated. Similarly, by taking some few years to accept flexible response and by reluctance to shift from that term, the alliance has allowed the United States to come full cycle back to the same label it accepted during the Kennedy years.

Flexible Response

Flexible response, in the NATO lexicon, derives from the "Overall Strategic Concept for the Defense of the NATO Area," Military Committee document MC 14/3, which proposed deterrence, direct defense at whatever level of aggression chosen by an attacker, deliberate escalation if aggression cannot be contained and the situation restored, and capability for appropriate general nuclear response to a major nuclear attack.[6] This last capability links strategic and theater nuclear forces, particularly in the view of European allies, in the concept of coupling. At the other end of the escalation spectrum is an increased emphasis on conventional strategy and military means.

> With the adoption of the strategy of flexible response in 1967, NATO embraced concepts for the defense of Western Europe predicated upon the deployment of strengthened conventional forces to respond to a Soviet-Warsaw Pact attack, without initial resort to tactical nuclear weapons or a strategic nuclear strike by the United States against the Soviet Union. [9]

The viability of a flexible response strategy to deter and defend under circumstances different from those in 1967 has come increasingly into question:

> Flexible response can continue to serve the alliance <u>if</u>, <u>and only if</u>, its tactical concepts can be made to accord with problems such as a significant reduction in warning time of an impending enemy attack, the threat to continuity of the air and sea lanes, and the need to operate along several fronts simultaneously ... [9]

> In recent years the problems of maintaining a viable strategy of flexible response for NATO have multiplied. They relate to such factors as changing perceptions of the threat confronting Western Europe, shifting power relationships and differences in policy between the United States and Western Europe, the emergence of a new generation in NATO countries with values different from those of the World War II and postwar generations, the increasing salience of economic constraints on defense budgets, uncertainty within Western Europe about the durability of the U.S. alliance commitment, and questioning in the United States of the need for preserving American forces stationed in Western Europe at existing levels. [9]

Relooking At The Strategy -- Deterrence

This questioning of NATO strategy and its ability to adequately deter and defend, while the Alliance displays solidarity and practices detente, is often an uneasy search of basic interests, evolving threats to those interests, and potential improvements in policy, strategy and forces to protect those interests, particularly with respect to nuclear aspects.[10] The last broad, official, published review of theater nuclear force posture in Europe provides basic assessments of NATO strategy and force employment concepts which are far from inexact or outdated today.[11] More recently,

> The present administration has spent a good deal of time considering what the strategic concept should be .... These objectives and policies are not predictions, forecasts, or iron-clad commitments. They constitute guidance designed to make our defense planning problem tractable, to ensure careful conservatism in our planning, and at the same time to keep from trying to attain defense capabilities which would far exceed those realistically necessary. [12]

> A theater nuclear capability is an essential element of successful deterrence and defense. Theater nuclear forces provide linkage between conventional and strategic nuclear forces. In the event aggression cannot be contained conventionally, theater nuclear forces provide a capability to fight the battle and an opportunity to terminate conflict short of strategic nuclear war. Theater nuclear weapons are deployed as an integral part of U.S. theater forces to strengthen the deterrent effect of forward defense and to augment conventional forces. [13]
>
> ...Our threater nuclear forces do not constitute a full-fledged and independent capability. They are, for the most part, organic to the general purpose forces. The longer range systems are integrated in targeting with the central strategic forces, many of which are programmed against theater targets. Thus, should their weapons be released, our theater nuclear forces would probably be used in conjunction with regular ground, tactical air, naval, and in many cases strategic forces. [14]

This theater nuclear linkage and capability for use lie at the center of the deterrent debate. In a manner similar to the early discussion of the objective denial/punitive orientation toward U.S. deterrent policy and strategy, the idea of NATO deterrence as an acceptable means to deter are not universally accepted within the Alliance. Additionally, the view supporting punitive deterrence tend to rely strongly on strategic coupling. Coupling of NATO deterrence to U.S. strategic systems was originally sound during the period of U.S. nuclear monopoly

and clear superiority -- no other weapon choice was realistic. As Soviet strategic capabilities grew, U.S. coupling became suspect (e.g., France opted for independent nuclear means). In an era of strategic parity and potential inferiority, coupling is no longer credible. The potential to escalate a European war to strategic exchange, which is the key to the deterrent view that unacceptable damage will preclude conflicts (or continuing conflicts) becomes much less likely than before. Objective denial, based in part on an ability to fight, might then be a firmer foundation for deterrence and defense.[15]

> ...while most British and West German officials, for example, tend to believe that the threat is deterrable largely by means of promises of escalating levels of punishment, American officials tend to believe that the threat is best deterred largely by the promise of (eventual) local denial....
>
> NATO-Europeans and Americans should be able to agree that territorial (and hence political) denial in a short war is their major problem...[16]
>
> West Germans view U.S. theater nuclear weapons primarily as a link to American strategic nuclear weapons, as an additional in-theater deterrent, and as a tangible symbol of the American defense commitment to West Germany. They are clearly not considered primarily as war-fighting weapons.[17]

Coupling, never truly a foolproof concept, relies on the credibility of U.S. commitment to use strategic capabilities; decoupling might therefore reflect a decreased U.S. resolve which, aggravated by relatively decreased strategic capability, constitutes a degraded deterrent. Whether explicitly decoupling strategic forces is necessary or wise, it would tend to increase

allied fears of U.S. abandonment, perhaps already implicit in the "neutron bomb" decision and the PRM-10 leak of a map indicating a not-so-forward defense.[18] By stressing, perhaps properly, the utility of objective denial, both concepts of forward defense and potential resort to nuclear weapons are re-supported, while deterrence and defense are strengthened. Through development of a credible warfighting capability, the Warsaw Pact could be denied success of any disarming attack and subsequent coercive advantage over Western Europe, particularly if the means of objective denial were highly survivable, perhaps by sea-basing them. If the long-range theater nuclear forces, assisting NATO strategic means, serve the purpose of a counterforce retaliatory capability, as well as being relatively invulnerable, particularly if deployed aboard submarines, the Soviet/Warsaw Pact objectives (disarm and coerce) could be denied and deterrence would be served. It is this capability to endure the initial attack and to subsequently defeat enemy forces which allows objective denial to successfully deter.

> ... The survivability, sustained combat power, pre-attack deployment, and post-attack planned employment of NATO strategic and general-purpose naval forces <u>are at the center of a U.S. deterrent strategy of denial type</u>.[19]

Of the four factors noted by Dr. Young, the first three accrue to force characteristics which will be covered in Chapters V and VI, while the last refers to how such a force is to

be used. Previously, the concept of limited and regional nuclear options (LNO's and RNO's) was cited as part of the planning resulting from the Schlesinger strategy and NSDM 242. The PRM-10 review by the current Administration and the gradual policy and strategy shifts published in Presidential Decision 18 have not been released in full; however, other published official reports, necessarily consistent with PD-18, provide insights into the current strategy. Specifically, the flexible response and selective options postulated in 1974-1975 for theater nuclear forces are similar to the current missions for which theater nuclear forces should be planned:

> --Limited Nuclear Options to permit the selective destruction of fixed enemy military or industrial targets;
> --Regional Nuclear Options intended, as one example, to destroy the leading elements of an attacking enemy force; and
> --Theaterwide nuclear options directed at aircraft and missile bases, lines of communication, and troop concentrations in the first and follow-on echelons of an enemy attack. [20]

Balance

The NATO strategy of direct defense at whatever level of aggression chosen by the attacker, as well as the principal of deterring by having balancing force capabilities at every level, suggests that critical imbalances deserve priority attention. Although there might be alternatives to the

theoretical need to balance at every level and capability, the United States and its allies tend toward direct defense and response in kind -- a talion, or balanced use in kind and intensity. There are cases where NATO has almost no talionic capability (e.g., chemical attack), just as there are some deficiencies in strategic and general purpose conventional forces. However, force capabilities exhibiting the most severe shortfalls on the U.S./NATO side appear to be in relatively long range (but not "strategic") forces which are principally nuclear capable and oriented on theater targets. The weapons arming these forces have been called non-central systems, forward based systems, peripheral attack systems, and gray area systems -- intending to describe systems with mid-range capabilities between the battlefield, or short range use at sea, and the strategic, or intercontinental.

> ...The Soviets maintain large, nuclear capable, peripheral attack forces based in the Soviet Union. These forces include medium-range bombers (in addition to the BACKFIRE discussed previously MRBM and IRBMs (including initial deployments of the new, mobile, MIRVed SS-20 ballistic missile), and older submarines armed with ballistic and cruise missiles .... NATO, by contrast, has few theater nuclear systems that can reach these Soviet forces. [21]

Similar concerns of the need to counter dramatic increases in Soviet theater systems have been expressed by many military officials and analysts.[22]

Filling the Deterrent Gap

> We and our NATO allies are presently examining our theater nuclear posture in the overall review inaugurated by the 1977 NATO Summit. We have major programs underway for the possible modernization of ... longer-range tactical nuclear forces, including ... various cruise missiles. [23]

> ...The major deficiency in NATO is ... the lack of a credible nuclear deterrent capability of striking deep into Eastern Europe. ...In my opinion, it is likely that a mixed force of ballistic and cruise missiles will prove to be the most cost-effective and viable response to the ever-increasing Soviet initiatives. [24]

The attractiveness of a European based, deep penetration system has transcended divergent views of deterrence (denial versus punishment), since such a system is envisioned to provide significant advantage over current, coupled strategic systems. Potential candidates include a new intermediate range ballistic missile, ground and sea launched cruise missiles, a mobile medium range ballistic missile, or extended range Pershing II.[25] Examination of the options by the Long-Term Defense Program Task Force 10, the NATO Nuclear Planning Group, and the (Task Force follow-on) High Level Group centers on the key security needs facing NATO:

> The enhancement of NATO's security must be assured not only by strengthening the Alliance's deterrent and defense posture but also by continued pursuit of detente and, as a key part of that process, equitable and meaningful arms control and disarmament agreements....NATO is determined

> to meet this challenge (shifting balance) by maintaining a credible deterrent and defense posture. NATO's capabilities will continue to be designed to support the concept of forward defense based on adequate conventional, theatre nuclear and strategic nuclear forces through the 1980's. [26]

Cruise missile contributions to the NATO security policy have been described in the three critical areas -- deterrence, defense, and detente through arms control:

> Deterrence: Substantial numbers of cruise missiles appropriately based may be a partial answer (to deter and balance Soviet gray area systems). Finally, I believe we must continue to work at level four, FEBA nuclear war, with both sides primarily using shorter range weapons....Perhaps cruise missiles in large volume can make an essential contribution to providing deterrence at that level as well.[27]

> Defense: ...U.S. cruise missiles could substantially strengthen the defensive posture of NATO....[28]

> Detente Through Arms Control: ...We and our NATO allies are carefully examining the adequacy of our longer-range theater nuclear capabilities, as well as considering how arms control can be of benefit in limiting the threat.[29]

The hedged words above (may be a partial answer, perhaps, could, examining, considering) require a somewhat deeper look at cruise missiles -- what they are and what tests of adequacy of support they must achieve.

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CHAPTER V

EVOLUTION OF THE CRUISE MISSILE

Improvements in weapons systems are generally designed to increase their range, accuracy, or destructive potential; there have been relatively few truly revolutionary weapons. Certain technological breakthroughs allowed rethinking of the "unmanned aircraft," the cruise missile concept from 1917 into the 1960's.[1] Dramatic improvements in microelectronics, airborne radar resolution, very high efficiency turbofan engines, better fuels, higher nuclear warhead yield to weight design ratios, and improved conventional munitions effects allowed the cruise missile to be shrunk in physical dimensions, while achieving longer range, lower profile, and higher accuracy flight. Critical military advantages accrued -- low altitude and small size contribution to higher survivability in flight; reliable and effective munitions with high accuracy contribute to target kill effectiveness. The potential utility of a new generation of cruise missiles resulted in a Navy program (SLCM or Tomahawk) and a revised Air Force program (SCAD) being merged under a Joint Cruise Missile Project Office. In particular, the Tomahawk program for sea launched cruise missiles (SLCM) later expanded to include broad research and development of other cruise missile variants applicable to theater use. Although Tomahawk is the Navy name only for SLCM, the same basic missile is common to other launch platforms. Therefore,

although not quite correct in a bureaucratic sense, this paper refers to those common missiles under the same title.

The Tomahawk Program

Since its initiation in the early 1970's (memos date from 1972), the Tomahawk cruise missile has built upon the technological evolution summarized above and discussed in more detail in Appendix A.[2] The evolving design challenge postulated accurately striking targets up to 2000 nautical miles from the launch point, high survivability, flexible variants (conventional/nuclear warheads and air/ground (surface/submarine platforms) at affordable cost.[3] Figure 5-1 illustrates the commonality of strategic air launched cruise missiles (ALCM), ground launched cruise missiles (GLCM), and sea launched cruise missiles (SLCM). Economy, implicit in commonality, was desired, although competing ALCM designs (Boeing and General Dynamics) were permitted, with a fly off to eliminate one design early in 1980. The strategic ALCM and the antiship version of the SLCM could have some secondary theater roles, but the GLCM and land attack variant of SLCM would have primary theater/tactical missions. These latter two derive from the Tomahawk (SLCM program) missile designed by General Dynamics Convair Division and described in Table V-1 and Appendix A.

FIGURE 5-1

TOMAHAWK LAUNCH VARIANTS

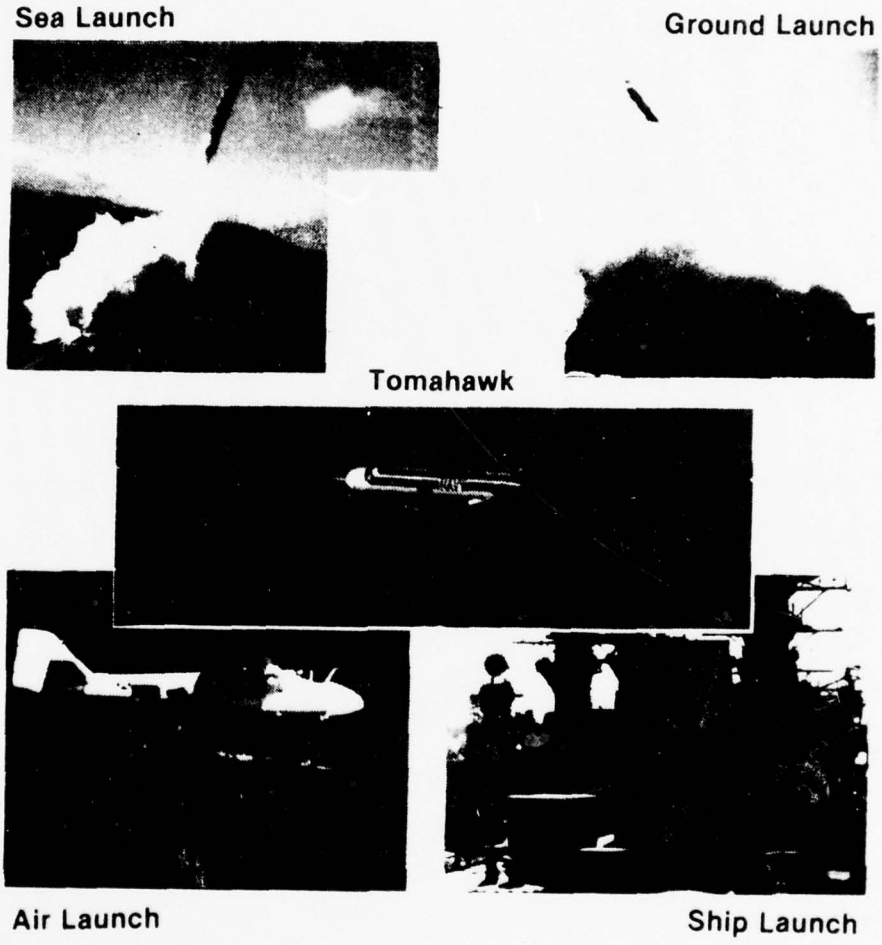


TABLE V-1

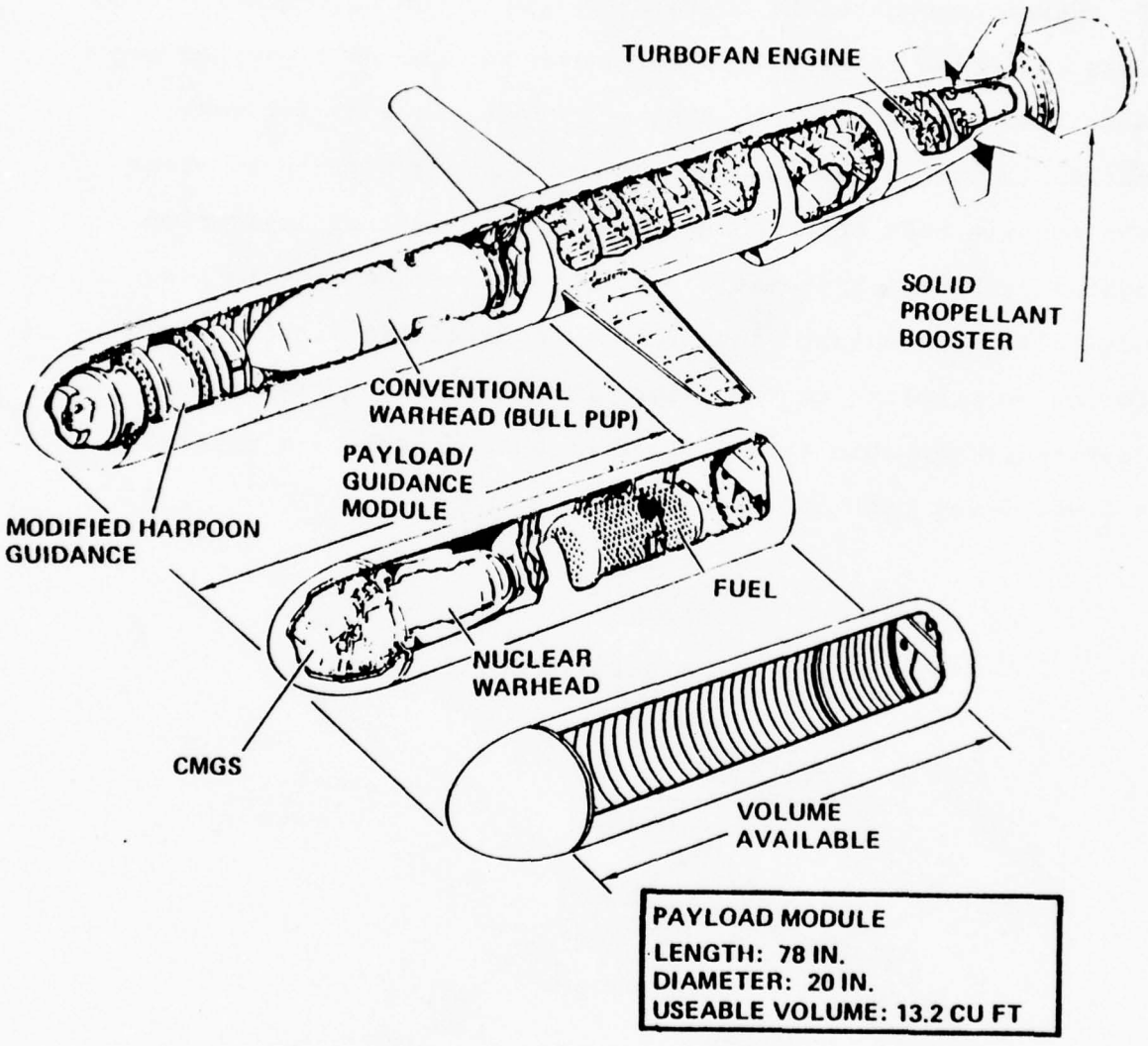
TOMAHAWK CHARACTERISTICS

Weight	3200 pounds (with booster)
Length	20.5 feet (with booster)
Diameter	21 inches
Speed	High subsonic (Mach 0.7 to 0.85)
Operational Range	600 Km (Conventional) 3000 Km (Nuclear)
Altitude	20-1000 meters
Accuracy	As low as 12-50 meters

The modular concept, shown in Figure 5-2, allows nuclear or conventional arming or some other payload (e.g., reconnaissance pod) to be attached to the common airframe. Guidance and terrain avoidance nap of the earth flight at very low altitude are provided from onboard radar signals and terrain contour matching (TERCOM) in the Cruise Missile Guidance Set (CMGS); terminal guidance is used in the antiship variant of SLCM. Note that the variant with the nuclear warhead weighing about 25% of the conventional warhead adds fuel and, therefore, range over the conventionally armed variant. Several such range tradeoffs exist, allowing increased range with (a) lighter and smaller warhead(s), (b) higher energy fuel, (c) higher altitude approach, and (d) slower speed.

FIGURE 5-2

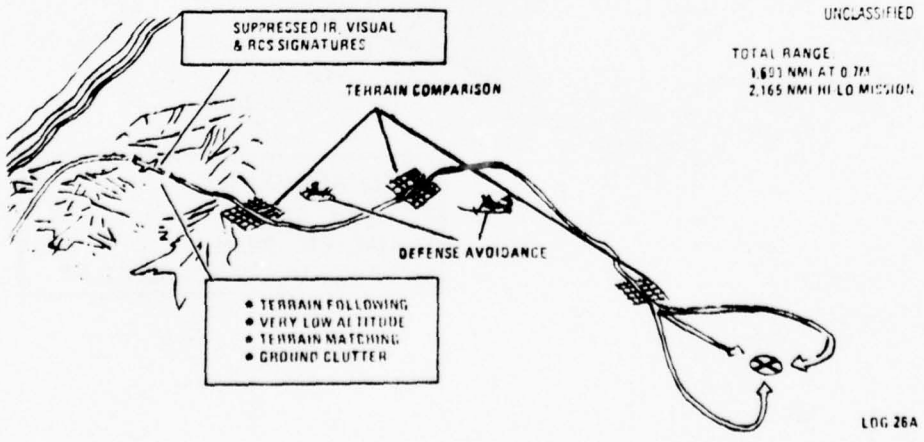
CRUISE MISSILE MODULES



The missile time of flight at long range would create unacceptable inaccuracy of a pure inertial system due to gravity anomalies which allow inertial platform drift. The inertial system is therefore updated by terrain contour matching(TERCOM). TERCOM uses real-time radar altitude returns and stored digitized map matrixes representing the same terrain elevations for comparison. Corrective guidance commands are generated to steer the missile back onto course, update the inertial navigation system, and bias systematic errors. The cruise missile need not follow a straight line, such as a ballistic missile would follow -- preplanning the flight path can take advantage of distinctly mappable areas, avoid known defenses, and maintain a lower level path as shown in Figure 5-3.

FIGURE 5-3

TYPICAL MISSION PROFILE



Accuracy is increased by decreasing the space between TERCOM update fields, reducing the cell size of update maps, and keeping the last map field close to the target to minimize inertial drift errors. Terminal accuracy on the order of half the cell size (theoretically a few meters) is sufficient for highly effective munitions delivery; TERCOM accuracies are estimated to be 12 to 50 plus meters. Figure 5-4 illustrates the mission profile with pre-programmed turns at way points, increasingly closer and finer grained TERCOM fields for accuracy, and survivability aspects.

High accuracy is critical in effectively killing hard targets with nuclear warheads, or in precise delivery of conventional or nuclear munitions on an area target. Hard target kill (K = kill factor) increases as the square of miss distance improves; as accuracy is doubled, the hard target kill factor increases by a factor of four -- if accuracy triples (CEP becomes one-third of the original), K increases by nine. The effect of accuracy is shown in Figure 5-5.

Reported yields for the W-80 cruise missile warhead (150-200 KT upper yield) coupled with reported accuracies (e.g., 50 meters) indicate a single shot damage probability of at least 0.99 for point targets hardened to withstand up to 4000 pounds per square inch peak overpressure (45PO).[4] With such accuracy, just a few kilotons could defeat 200 psi sensitive targets while limiting undesired collateral damage effects.

The large variety of available improved conventional munitions described in Appendix A provide non-nuclear options

FIGURE 5-4

LAND ATTACK MISSION PROFILE

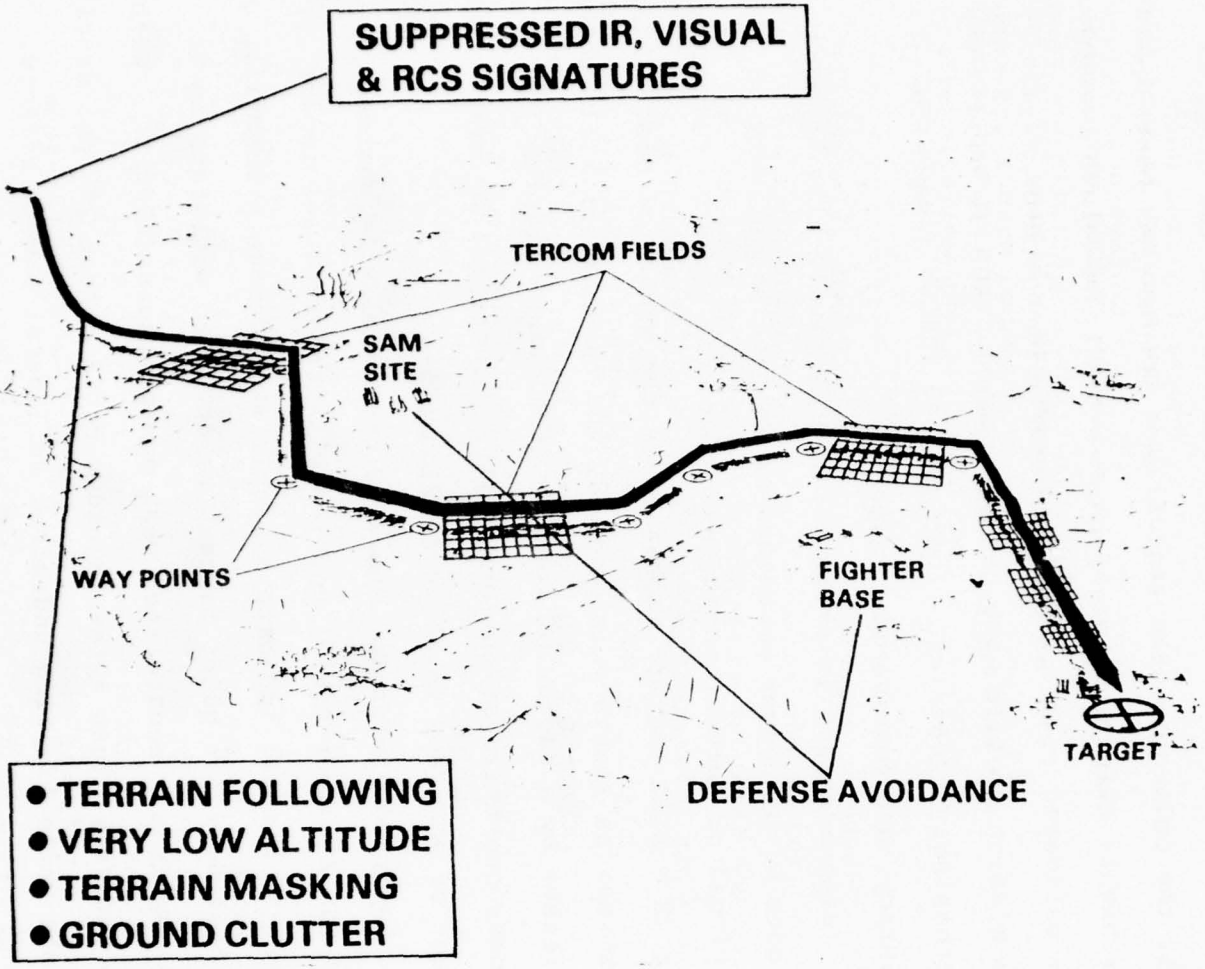
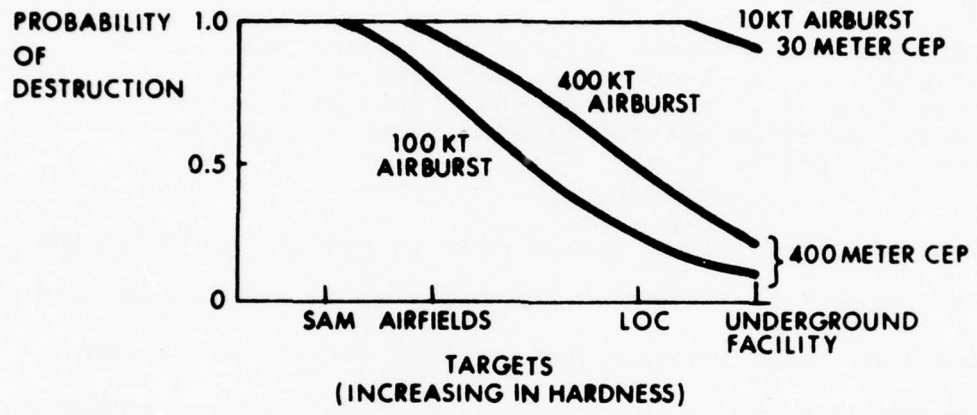


FIGURE 5-5

ACCURACY EFFECTS *



* Adapted from Cecil I. Hudson, Jr., and Peter J. Haas, "New Technologies: The Prospects," Beyond Nuclear Deterrence (Crane, Russak and Co., Inc., New York, 1977), p. 120.

The large variety of available improved conventional munitions described in Appendix A provides non-nuclear options for effective attack of airfields (proven in tests), vehicle targets, and personnel.

> Even before I became Secretary of Defense, I expressed the opinion that in some conventional application against high-value, highly defended targets, cruise missiles -- even though they may cost one million dollars a crack--would be more effective than manned aircraft. As time has gone by, I have become more and more convinced that there will be conventional applications for cruise missiles against fixed targets as well as moving targets. [5]

Conventionally armed cruise missile attacks on advancing reserve forces, air defenses, logistics units and stores, and opposing long range weapons systems with anti material and anti-personnel submunitions with coverages of several thousand square meters provide non-nuclear options which could:

- Effectively defeat a wide variety of targets.
- Keep collateral damages low through accuracy.
- Decrease the risk of escalation to nuclear warfare.
- Raise the nuclear threshold by use of effective conventional means.
- Decrease incentives for nuclear proliferation.
- Contribute to stability.

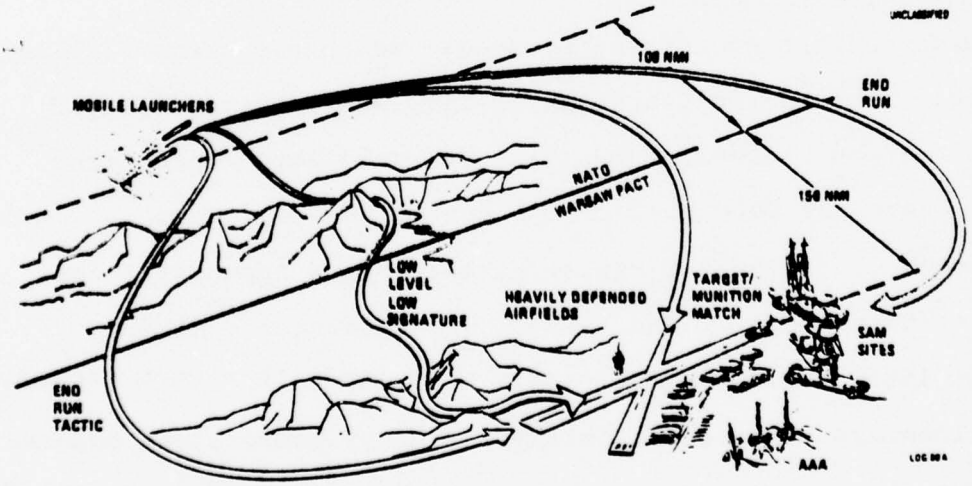
Conventionally armed cruise missiles are necessarily limited to a shorter range than nuclear variants, since the much larger warhead payload (1000 pounds versus 200-300 pounds) and terminal guidance system (200 pounds versus 100 pounds) displace available fuel space and weight. There are, however, numerous high value theater targets of the types noted above which lie outside the

range of other conventional systems (e.g., Lance surface to surface ballistic missile). Attack by relatively affordable unmanned cruise missiles might be preferable to engagement through strong defenses by tactical aircraft.

The majority (80-90%) of targets of interest are soft (12 psi, 13P1 or less), although the Soviets and Pact nations appear to be hardening certain installations. Mobile targets, with the exception of tanks, are also soft and therefore susceptible to attack by high explosive, concussion, or fragmentation munitions. Dual purpose (anti-personnel and anti-material) and anti-tank sub-munitions can provide high probability damage to a wide variety of area target elements, as suggested in Figure 5-6.

FIGURE 5-6

POTENTIAL CONVENTIONAL MISSIONS



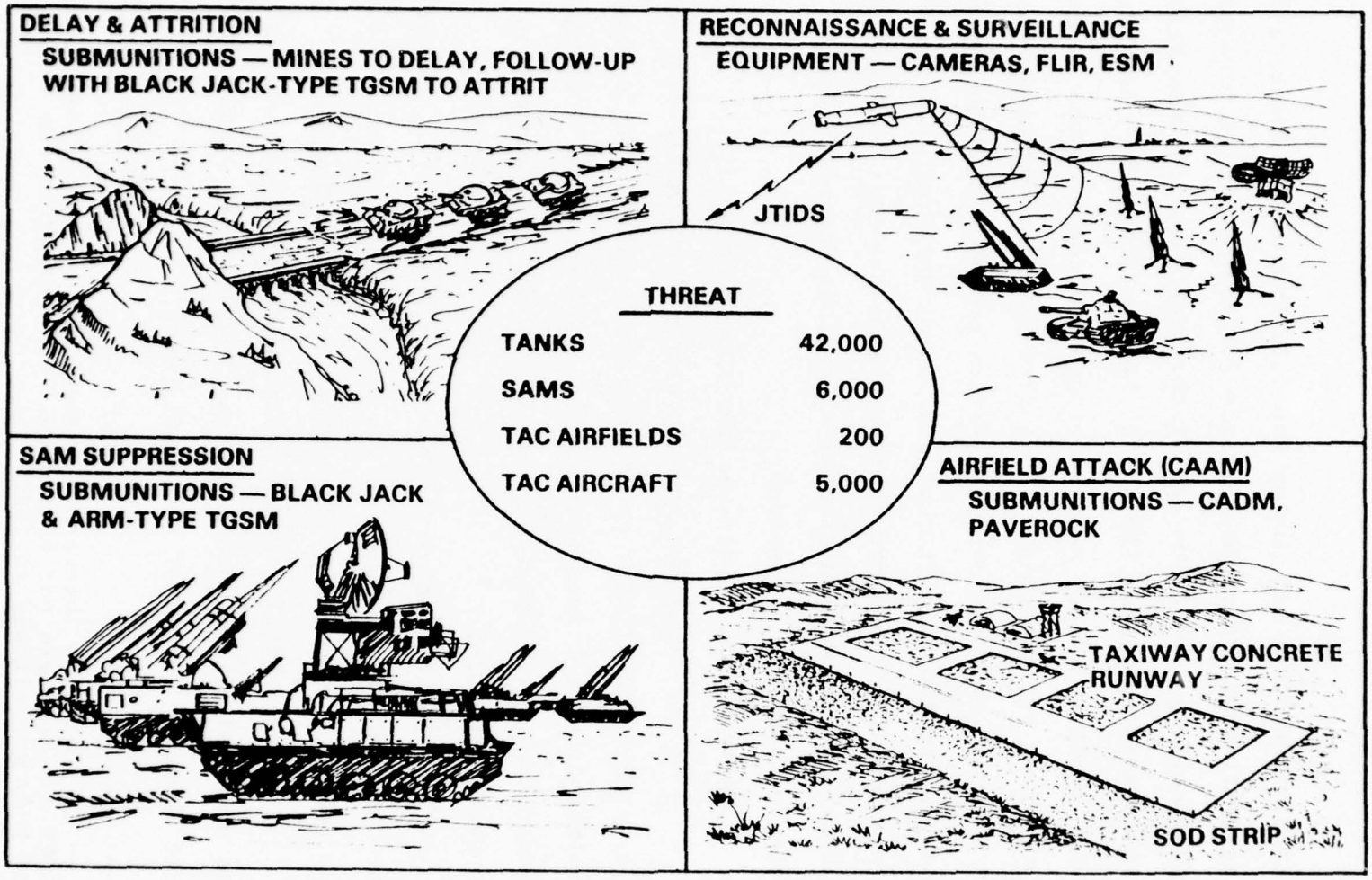
Cruise missiles can be militarily effective in both nuclear and non-nuclear configurations. Long range nuclear attack capabilities are particularly adaptable to hard targets, although long times of flight limit this to a retaliatory, non-preemptive mode, which may be more stabilizing than first strike systems. Battle area and interdiction targets could successfully be acquired with cruise missile surveillance pods and subsequently attacked with nuclear or conventional munitions, as suggested in Figure 5-7. Since they could be so effective, cruise missiles have become a stumbling block in negotiations to limit certain weapons systems and launchers. The first prerequisite to proposing theater cruise missile forces must therefore determine their allowability.

Arms Control Implications

Negotiations concerning strategic weapons systems, Strategic Arms Limitation Talks (SALT), and forward deployed general purpose forces, Mutual and Balanced Force Reductions (MBFR), have the potential for limiting the near term deployment of theater cruise missiles (see Appendix B for a fuller treatment).[6] The SALT II Treaty language allows through 1985, deployment of cruise missiles with ranges exceeding 600 kilometers on aircraft defined as heavy bombers and counted as MIRVed launchers. The number of bombers with long range ALCM plus MIRVed ballistic missile launchers would be limited to

FIGURE 5-7

BATTLEFIELD AND INTERDICTION USES



1320. Therefore the Minute Man III, Poseidon/Trident, and aircraft cruise missile carriers (CMC) mix must be managed, particularly toward the end of the treaty period when Trident SSBNs are deployed. About 3000 ALCM on about 100 aircraft would seem to be the maximum programmed force. Long range ground or sea-launched armed cruise missiles may be developed and tested, but not deployed, under provisions of the accompanying Protocol. After expiration of the Protocol, the Treaty terms on ALCM might appear to continue the ban, through 1985, on deployment of GLCM or SLCM with range capabilities of greater than 600 kilometers.*

Certain SALT II definitions should be noted:

-- For verification purposes cruise missile carriers (e.g., B-52) must have externally observable, functionally relatable differences from similar airframes used for other purposes (e.g., bombs only) or all of the type would count as MIRVed launchers.

-- The number of ALCMs allowed per CMC will not exceed an average of 28 counted as the total number of ALCMs divided by the total CMCs; B-52's are restricted to 20 ALCMs.

-- The 600 kilometer cruise missile range limit will be measured as the actual zig zag flight path, rather than the launcher to target radial distance.

---

* Author's interpretation; others hold that long-range GLCM and SLCM are not specifically addressed in the Treaty, so they are allowed in 1982.

-- Long-range GLCM and SLCM, banned from deployment by the Protocol and perhaps later by the Treaty, include conventionally (high explosive) armed and maybe reconnaissance missiles, as well as nuclear warhead equipped missiles.

-- Circumvention of SALT II terms through transfer of technology to allies may be charged by the Soviets.

Although equal numerical limits have been established in SALT II, some of the numbers (e.g., cruise missile range of 600 Km) seem to unequally restrict arms programs. The U.S. might, if unconstrained, plan for a long-range GLCM in the early 1980's as an add-on force in Europe to balance the Soviet SS-20, SS-22, and BACKFIRE, which are not counted in SALT. Soviet cruise missiles, already deployed on aircraft, surface ships, submarines, and ground launchers, are allowed by the thousands since their ranges are (generally) shorter than 600 Km. These Soviet systems currently can cover 69% of the U.S. population and all of Europe and Japan from the 100-200 fathom line; 600 Km U.S. cruise missiles could threaten most of the non-Soviet Warsaw Pact (GLCM plus SLCM), but only 15% of Soviet population (European based GLCM could not threaten Soviet soil).

Whether SALT II is truly equitable or not, even though generally equal numerical constraints apply to the U.S. and Soviet forces, a more critical debate exists concerning whether the terms can be verified or not. It is virtually infeasible, without on-site inspection, to determine whether

a cruise missile, specifically Tomahawk, contains a nuclear warhead, a conventional warhead, or a reconnaissance package (the arming issue). It is therefore impossible to determine its maximum range capability. A GLCM or SLCM can be identical to an ALCM, if the booster and capsule are separated from the missile. Any aircraft with bomb racks/pylons might carry ALCMs from allowable reserve stocks. Transfer of hardware or blueprints for allowed short range cruise missiles would not guarantee that subsequent modification (to add fuel and range capability) would not occur. The potential for breakout (the rapid and abrogating deployment of banned weapons systems) does not appear to contribute to stability.

Ratification of the SALT II Treaty is the subject of extensive public debate, with equity and verification receiving considerable attention. If SALT II is ratified, or the terms related to cruise missiles otherwise adhered to, long-range theater cruise missiles could be deployed after 1981; until then, shorter range cruise missiles could be deployed aboard surface ships, submarines, or on land based launchers.

Survivability

Even though arms controls might allow deployment of cruise missiles, a high confidence of survivability must be provided prior to fielding or deploying such forces.[7] Assessment of pre-launch survivability (PLS), inflight survival or probability to penetrate (PTP), and vulnerability to terminal

defenses is highly complex, scenario dependent, and subject to question. Evaluations range from elaborate computer simulations, rich in technical detail and reassuring in their three significant digit outputs, to primarily subjective assertions based on more qualitative factors. The former, generally classified due to sensitive weapons systems data and intelligence inputs, are needed to provide defense planners with extensive reassurances concerning large dollar force decisions which must be made under conditions of uncertainty. The latter, generally less specific and unclassified, are useful in confirming previous biases which can accept some lower degree of confidence. Both should address all pertinent factors affecting vulnerability in pre- and post-launch environments.

Pre launch survivability of theater cruise missiles differs due to launch platform peculiarities. Factors important to PLS include hardening, dispersal, concealment, defenses, and mobility.

GLCM warhead storage, whether nuclear or conventional, is subject to peacetime economic pressures to consolidate sites for increased security and safety. Additional lighting, as well as consolidation, decreases survivability against a surprise, bolt-out-of-the-blue attack. GLCM delivery units are similarly tied to cantonment areas. Camouflage and dispersal are therefore infeasible, with hardening and defensive security forces providing the only peacetime protection of ammunition.

Once alerted, GLCM forces can take advantage of dispersal, concealment, and mobility in field locations. Since GLCM units have few vehicles, they are less detectable. Their range capability coverage allows dispersal relatively well to the rear, where enemy target acquisition is less capable. GLCM survivability should be better than other missile delivery units ashore. SLCM PLS would be even higher.

Penetrativity, penetrability, and inflight survivability are relatively interchangeable terms with probability to penetrate (PTP). The most serious debates concerning cruise missiles focus on PTP, with worst case, safe-sided estimates being very low and cruise missile optimistic assumptions suggesting very high PTPs. The factors influencing assessment of PTP are listed in Table V-2.

TABLE V-2

FACTORS INCREASING PTP

Cruise Missile	Air Defenses
Low Altitude	Terrain Masking
Terrain Following Maneuverability	Ground Clutter
Defense Avoidance	Low Antenna Height
High Subsonic Speed	Lack of Moving Target Indicator
Low Radar Cross Section	Poor Signal To Noise Ratio
Low InfraRed Signature	Low Power - Aperture
Low Visual Signature	Wide Angle Resolution
Zig Zag Approach	Low Frequency Radar Backscatter
Multiple (Saturation) Attacks	Tracking Radar Multipath
	Missile Fuzing At Low Altitude

The capability to fly low terrain following paths is the key contributor to cruise missile survivability. The radar altimeter monitors vertical altitude and uses its rate of change to maintain a very low and level flight over water and flat earth. Increased average altitude is required over rougher terrain to avoid "clobber" (flying into hills). Terrain following trades off the risk of clobber with the risk of air defense detection and engagement. Low infrared and radar cross sections of the cruise missile, coupled with low altitude generated problems of acquisition radar ground clutter and masking, tracking radar multipath anomalies, and untimely air defense missile fuzing, contribute to in flight survivability. In addition to technical capabilities, systems associated with air defenses can degrade surface to air missile (SAM) or aircraft interceptor effectiveness. The lack of (or imprecise) early warning data, overloaded communications, poor ground control intercept netting, interfering electronic counter measures from aircraft in the area, and human inefficiency or exhaustion tend to be convincing reasons to choose cruise missile optimistic sets of PTP assumptions. Under Secretary of Defense Perry concluded that most (half to two-thirds) of a large (1000-3000) cruise missile attack would penetrate a $30-50 billion upgraded Soviet air defense system protecting the Soviet Union against strategic ALCM. The current system, which cost about $100 billion to construct,

is considered virtually useless against the cruise missile. Deployment of theater cruise missiles (GLCM/SLCM) would severely compound the Warsaw Pact air defense problem in Eastern Europe, perhaps necessitating another $20-30 billion invested in the theater outside the Soviet Union. Recent reports of look down, shoot down air defense aircraft intercept tests have been cited as tests against drone aircraft, with questionable projected utility versus much lower altitude, smaller cruise missiles.

Newer SAMs (SA-10, SA-11) may have some limited capability, particularly in terminal defenses. However, even with a maximal detection range of 20 Km, immediate response, and a straight-on shot, the total terminal defense SAM system has less than 100 seconds to counter the arriving cruise missile.

Overall survivability, being scenario dependent and technically complex, probably is best cited in non-numerical terms. PLS after alerting appears generally very high for theater cruise missiles compared with other systems. PTP would seem to be better than aircraft, worse than ballistic missiles, and economically acceptable overall. Key factors contributing to high survivability include dispersal in depth, mobility, concealability, low altitude flight, low radar cross section, low infra-red and visual signature, high subsonic speed, and non-straight line flight path.

Other Implications

Platform flexibility, noted previously, allows considerable latitude in cruise missile basing options. Both surface and submarine platforms could be deployed in support of allies around the world, perhaps part of those forces consisting of NATO or other allied vessels and crews with U.S. nuclear custodians for European support or non-nuclear support elsewhere. Ground based forces would politically be less redeployable to respond to out of sector contingencies; however, GLCM forces are probably cheaper in terms of peacetime operations and logistics support than dedicated SLCM forces. Long range cruise missiles would allow widely dispersed basing of European theater support forces to provide flank coverage (e.g., from the United Kingdom and Greece or contiguous waters), as well as allowing overlapping central front capabilities and deep, Eurostrategic coverage. Alternatively, proximate cruise missile units (e.g., the major surface combatants of a 2-3 carrier battle group) could provide an arc of relatively more intense coverage than widely dispersed forces. Allied participation, in cruise missile forces as well as basing, would strengthen defense and other ties through the sharing of burdens, increased defense capabilities, and potential risks.

Affordability is becoming central to most U.S. and allied defense programs. As can be seen from cost data included in Appendix A, the several cruise missile budget lines have been expensive and could continue to be so. It is

doubtful that the per unit cost of GLCM or SLCM versions of Tomahawk could reasonably be decreased to under $1 million, suggesting that total force buys would be somewhat limited. On the other hand, forces with several hundred to a thousand theater cruise missiles could provide a relatively economical complement to existing forces (e.g., Pershing, dual capable tactical aircraft) which also are expensive. Commonality (e.g., the Command Missile Control System) would lower costs. By expanding the number of targets that could be defeated, some future cost benefits might argue for more cruise missiles; however, relatively constant personnel ceilings and constrained budgets might result in more modest forces.

Cruise missiles are postulated as complements to other theater systems, being more survivable but less flexible than more expensive but reloadable manned aircraft and more flexible but slower than ballistic missiles. They compound enemy defensive problems and broaden the threat spectrum. In a fiscally unconstrained world, an add-on theater cruise missile force would be feasible and desireable; perhaps with the advertised savings projected to accrue due to SALT, part of the $30 billion over ten years might still allow such add-on forces. A more pragmatic assessment might conclude that already lean defense budgets of the United States and allied nations are structured to allocate shortages to a host of important programs. The implicit competition for scarce resources suggests that services might need to forego or delay portions of other programs to acquire cruise missile forces.

Theater cruise missile forces could be dispersed and postured as part of the NATO Quick Reaction Alert (QRA) force, potentially freeing some of the less visible or more expensive to operate systems from that role. Dual capable aircraft tied to QRA (at increasing levels in higher alert stages) could be reallocated to close air support roles which are critical early in a European conflict. Invisible Poseidon forces committed to SACEUR could potentially be returned to purely strategic roles. In the process, QRA might be redefined to include non-nuclear cruise missile coverage of critical fixed Warsaw Pact targets previously covered by nuclear systems, thereby raising the nuclear threshold.

Provision of both nuclear and non-nuclear (conventional) capabilities to theater cruise missile forces would increase their flexibility. In limited war, or non-nuclear phases of a potentially escalating conflict, it makes little sense to restrict any nuclear capable force only to its nuclear role. If escalation control works, possession of dual capability could increase theater cruise missile defense capabilities. For those allies not normally inclined to participate in nuclear activities (e.g., Norway, Japan), conventional-only cruise missile support could be provided, although the shorter range would imply a generally more defensive and tactical, less "strategic" role.

Stability, particularly during crises, should be enhanced by the presence of long time of flight cruise missiles which cannot have a surprise or disarming capability. A partially offsetting feature, potentially destabilizing, is their great accuracy and resultant hard target lethality. Since theater GLCM forces would be highly vulnerable to preemption, their accuracy and peacetime vulnerability may provide preemption incentives. Attempts to disperse GLCMs in a crisis to improve their survivability might be perceived as preparation for use, compounding the destabilizing effects. In addition, movement of GLCM forces to rear areas might be seen as a lack of resolve reflected in retreat, thereby encouraging intensified coercion or conflict. The Soviet homeland threat posed by long-range GLCM or forward deployed SLCM forces is often cited as strategically destabilizing, since their use might result in retaliatory strikes on the United States. Doubts exist concerning the perceived sanctity of the Soviet homeland, particularly in view of the Soviet proclivity to retain long-range theater attack systems (e.g., SS-4, -5, -20, -23A) on Soviet soil. This implies that theater originated counterstrikes might be at some less-than-strategic/vital level in Soviet minds, not resulting in strikes on the United States.

Arguments concerning an arms race stimulated by plans to deploy GLCM and SLCM tend to emphasize fears of Soviet reactions to increase theater attack systems. Current Soviet

missile modernization and deployments include 100 SS-20 with 3 MIRVs deliverable to 5000 Km to augment older SS-4 and -5 missiles, the short range SS-21 to replace FROG, the 150 mile SS-22 to replace SCUD, and the longer range SS-23A to replace SCALEBOARD, with a one year increase from about 1300 to more than 1600 launchers in Europe.[8] It is difficult to conceive of reactive Soviet acceleration, although some defense budget money will probably be reallocated from Soviet strategic programs constrained by SALT to such theater force programs.

Cruise missiles, being very accurate, provide high confidence of destruction of a wide variety of targets using nuclear or non-nuclear warheads. Relatively high survivability of SLCM and GLCM enhance the military capabilities necessary for deterrence. The other principle deterrent prerequisite, political will or credibility of potential use, must be perceived by U.S. allies and enemies alike as sufficient to pose an unacceptable risk to achievement of enemy theater objectives. Clearly enunciated statements of resolve, such as those noted earlier, need to be backed by decisive actions to demonstrate the validity and credibility of stated U.S. overseas commitments. Acquisition programs for theater cruise missiles and personnel programs to staff deployed or deployable delivery forces lead to enhancing deterrent policies.

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CHAPTER VI

ROLES AND MISSIONS

> U.S. land forces (Army and Marine Corps) are needed to counter Soviet/Warsaw Pact ground forces in Europe as part of the NATO alliance. No other contingency places so great a demand on land forces, and no other, short of an attack on the U.S., is so critical to the vital interests of the United States. As the only military forces capable of holding or taking territory, the land forces are the mainstay of our conventional deterrent and war-fighting capability....
>
> Naval forces contribute to national security objectives across a broad spectrum of National Military Strategy. Prominent among Naval roles supporting National Military Strategy are forward deployment, measured projection of power against the shore, superiority at sea in a crisis setting, defense of sea lines of communication, reinforcement of allies, pressure upon the Soviets, and hedge against uncertainties of the distant future....
>
> The missions of tactical aviation include controlling friendly airspace, and supporting land and sea forces in the execution of their missions. The ability of tactical air forces to counter attacks varying widely in location and intensity provides a major element of flexibility in our general purpose force capabilities.
>
> Harold Brown
> DoD Annual Report FY 1980

Roles

The historic roles and missions of the military services outlined by the Secretary of Defense derive from

DoD Directive 5100.1 and Title 10, United States Code. Cruise missile programs contained in the same DoD Annual Report present new views of how the Services are to accomplish their task. In a parochial sense, the Services tend to look upon the cruise missile as a threat to their preferred force programs, either as a direct competitor or as a system which could consume scarce and relatively fixed resources.

Cruise missiles also may challenge some cherished traditions of the Services, increasing internal reluctance to support additional funding or to accelerate deployment of cruise missile forces. ALCM, the strategic B-1 killer, can hardly seem to be attractive to senior Air Force officers whose success has accured from flying air defense penetrating aircraft. GLCM, carried as an Air Force general purpose force program, competes with dual capable tactical aircraft and necessitates adoption of Army-like standard doctrine and tactics in the theater environment. SLCM is an implicit alternative to Navy and Marine Corps tactical aircraft and presents an extended land attack support potential for surface combatants and submarines, diverting funds for traditional roles. The Army tends to concentrate on battlefield systems, with the exception of the Pershing surface-to-surface missile system.

In a more positive vein, the Services have accepted new roles and recognized the cruise missile potential to

support overall defense policies and national interests. ALCM has been accepted as an innovative and effective contributor to the air breathing leg of the strategic Triad and GLCM and SLCM have been recognized as strengthening links to interservice support capabilities.

SLCM Roles

Roles for sea-based Tomahawk could include anti-ship attack (conventional warhead), destruction of naval targets ashore, long-range theater nuclear force interdiction (particularly on NATO flanks), battlefield support (nuclear or conventional), and post-attack reserve forces for potential employment following a general nuclear exchange. Such roles could significantly enhance deterrence, being militarily effective, survivable, controllably discriminate, and flexible. The emplacement of SLCM on numerous surface ships, not necessarily only aboard combatants, and submarines could spread the force projection fire support capability from a dozen carriers to potentially hundreds of vessels, diffusing the current threat directed primarily at carriers. By proliferating long-range attack platforms, wider target coverage, cross-targeting, and temporary concentration or massing of fires can support ground operations.

> In the past, the size of a warship and its throw weight of shells were dominating factors. But today size is of less importance since even small ships can mount long range missiles....Most

> U.S. warships can be armed easily with a cruise missile such as TOMAHAWK since their maintenance and firing operations would place few additional demands on ship crews.[1]

> With the development of the Harpoon and Tomahawk land attack missile, every combatant ship, submarine, and aircraft has a potential offensive role, a role previously possessed only by carrier based aircraft.[2]

> No longer do we have such clearly defined roles for air, surface, and submarine forces as existed in the past....We must...find ways as the Soviets have done, to build a total force at sea that includes coordination with the merchant marine, the Coast Guard, the Air Force, and the Army in a way similar to our Navy-Marine Corps team concept.[3]

The expansion of Naval roles is perhaps not so dramatic as envisioned by some; the worldwide sea control and power projection missions long held central to the bulk of Naval forces (SSBNs excluded) would be well served by adding cruise missiles to the surface fleet and attack submarine forces. The easily deployable power potential of SLCMs aboard such vessels reflects the inherent adaptability and flexibility of the Navy, and although some argue that assignment of SLCM missions could detract from other missions (e.g., ASW for attack submarines, convoy protection for surface combatants), concurrent roles are compatible.

GLCM Roles

GLCM roles and missions fit nicely with standard Air Force tasks of interdiction and close air support. The

perturbing nature of the Air Force GLCM lies in the tactics of deployment, which are more like those of Army units armed with surface-to-surface missiles (Lance and Pershing). With the recent approval for extended range Pershing (about 2000km maximum) for the Army and the SALT II initial GLCM range limit (less than 600km), it could be argued that a swap is in order to more closely align weapons range with historic Army/Air Force roles. (To further compound the roles and missions issues, note that additional missile interdiction capability in Europe is provided by U.S. Navy Poseidon SLBMs, German Air Force Pershing, and other national, e.g., British, strategic missile forces). An ancillary GLCM role might be in the anti-ship task currently reserved to SLCM, in particular, coastal defense of flank nations.

Missions

Regardless of the assigned roles, the warfighting capability of theater cruise missiles could be applied against a large variety of critical land targets. Enemy forces essential to achieving theater territorial objectives can successfully be engaged and defeated by a combination of cruise missile and other forces. The enemy's perception of this denial capability is crucial to deterrence.

If the perceived capability to accomplish assigned roles and mission is seen as lacking in resolve, deterrence could fail and the capability might need to be

employed after post-attack resolve is strengthened. Whether in Europe, as a NATO scenario, or in some other theater, in-place deployed theater cruise missiles could provide SAM suppression (to increase friendly aircraft survivability), airfield interdiction or pin down (to assist in gaining air supremacy), counters breakthroughs (to prevent exploitation of penetrations into rear areas), attacks of second echelon reinforcements or reserve ground forces, and neutralization of missile sites, lines of communication, logistics installations, and command centers in rear areas.[4] These missions could be performed by GLCM or SLCM, with escalation controlled by using conventional warheads wherever practicable. As previously noted, most of the fixed targets and essentially all mobile targets are relatively soft and therefore theoretically defeatable by submunition armed missiles. A dilemma arises in that the use of non-nuclear munitions can be argued to stimulate warfare:

> Raising the nuclear threshhold might lower the threshhold of conflict itself, if it were believed that extensive conventional operations could be carried out with little risk of escalation to the nuclear level.[5]

That thesis is at least partially countered by its author, who notes that, despite desires to control escalation

through conventional-only systems, the implicit decrease in American nuclear commitment might induce independent allied escalatory (nuclear) options, which could complicate the currently two-sided strategic problem. Conventional-only roles therefore seem as unattractive as nuclear-only roles, wherein nuclear forces must survive conventional conflicts and might not then be used. Additionally, the choice of using or losing unengaged nuclear weapons might tempt unnecessary escalation. Political reactions of allies could be managed, in part, by sharing the burdens and benefits of cruise missiles, as previously suggested. Outright sales of conventional hardware and implementation of nuclear programs of cooperation (POC) with previously accepted NATO countries could ease the resource drain on the United States while simultaneously increasing friendly defense and deterrent capabilities. In particular, Great Britain may be searching for replacements for aging strategic systems. NATO allies sense a need for long-range systems to counter new and increasing Soviet threats. It should be noted that POCs are <u>not</u> the same as the Multi-Lateral Force (MLF) concept denounced by opponents of nuclear sharing; POCs currently exist with certain NATO allies, who provide delivery means (e.g., missiles purchased from the U.S. or their own aircraft).

for potential delivery of U.S. nuclear warheads retained in U.S. custody until released by the President for imminent use.

In addition to considering allied reactions to cruise missile roles, missions, and capabilities, Soviet concerns deserve a cursory look.[6] Even short range (less than 600km) conventionally armed GLCM and SLCM could pose a future threat to perhaps 15% of the Soviet populace and industry, most targets in the non-Soviet Warsaw Pact (WP) nations, and Soviet aligned nations. The current threat posed by carrier-based and land-based tactical aircraft has been met by extensive air defenses, but an add-on very low altitude defensive capability would be very expensive, diverting funds from other WP programs. Longer range conventionally armed cruise missiles might be a viable option in the early 1980s, followed by nuclear armed missiles in the mid 1980s, which would be of greater concern. Political reactions (e.g., Soviet hard line in SALT), military response (e.g., increased air defenses), and peripheral actions should be anticipated; however, Soviet actions due to U.S. cruise missile plans might not be notably differentiable from their actions in a cruise missile-free environment. Whether U.S. or allied cruise missile programs are provocative or destabilizing, the lack of such programs in the face of

increased Soviet theater force programs would seem short sighted.

The vehemence of Soviet concerns might be the best possible gauge of the deterrent value of cruise missiles.

> U.S. military-political leaders, in striving to achieve a considerable advantage over the USSR in sea-based strategic forces, made a decision on the need to develop strategic cruise missiles with a range of about 3,000 kilometers.... As is seen from this and a multitude of other assertions [sic], the concept of 'deterrence' and its frequently employed synomyns, means nothing other than maintaining a constant readiness to immediately employ nuclear weaponry against the most important strategic objectives...the military-political leadership of the United and Great Britain look on the navy as a means possessing a high survivability and great versatility in carrying out missions in a world-wide nuclear war.[7]

Soviet fear of survivable and versatile capabilities, such as those possessed by cruise missiles, lie at the center of obdurate SALT demands to limit such weapons.

> One of the major reasons the Soviets have been so adamant about halting the U.S. cruise missile program is the concern that the cruise missile will be deployed on the West German plains with nuclear warheads to replace U.S. aircraft now standing alert in Europe.[8]

The QRA mission foreseen for GLCM substantiates reported Soviet fears of U.S. and allied motives for GLCM (sometimes referred to as the German Launched Cruise

Missile, fueling, Soviet xenophobia). Their simultaneous refusal to address Soviet non-central systems targeted on Western Europe, coupled with increasing demands to restrict cruise missile options are indicative of the roles and missions capabilities perceived by the Soviets. "Moscow insisted that nuclear armed cruise missiles be range-limited [to 600km] in SALT. Next, the Soviets demanded that these range limitations apply to missiles with non-nuclear warheads."[9] By limiting treaty allowable long-range cruise missiles only to ALCM, including GLCM and SLCM in the "temporary" Protocol, and then unilaterally declaring the permanence of the terms of the Protocol, Soviet intentions to preclude forward based cruise missiles become clear.

Theater Cruise Missile Forces

Original SLCM and projected GLCM procurement have been delayed, decreased, and shifted over the last 2-3 years, with initial operational capability (IOC) dates pushed into the future, build quantities decreased, and the Tomahawk land attack missile (TLAM) procurement deferred. Competition for scarce budget dollars, technological difficulties, extended testing, and arms control implications have caused program modifications.

GLCM, as a long-range system, shows procurement money in the early 1980s (see Appendix A), with the total planned buy of 696 missiles* allowing force IOC in about 1985. Actual delivery to inventory, which necessarily lags procurement by 1-2 years, and delivery to trained crews overseas would probably not allow full operational capability of the first USAF squadron until late 1984. This presumes that basing, construction, host nation support agreements, consistent target acquisition and communications, and operational plans could be completely settled by then. This highly doubtful set of circumstances suggests that the long-range GLCM IOC would in fact be slipped to post-SALT II instead of the earlier projected date (1983[10]), particularly in view of technical difficulties. GLCM is planned for development in a road mobile transporter, shown in Figure 6-1. The selection of a four missile per TEL load would appear to minimize the number of personnel assigned per missile, thus keeping operations and personnel costs down, with an upper mobility limited by gross mobility weight, perhaps 25-30 tons. The organization of TELs and launch control and communications (LCC) vehicles follows the square (four missiles per TEL) principle, with the flight shown in Figure 6-2, less the second (back up) LCC.[11]

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* As of early 1979; later reduced.

FIGURE 6-1

GLCM TRANSPORTER ERECTOR LAUNCHER

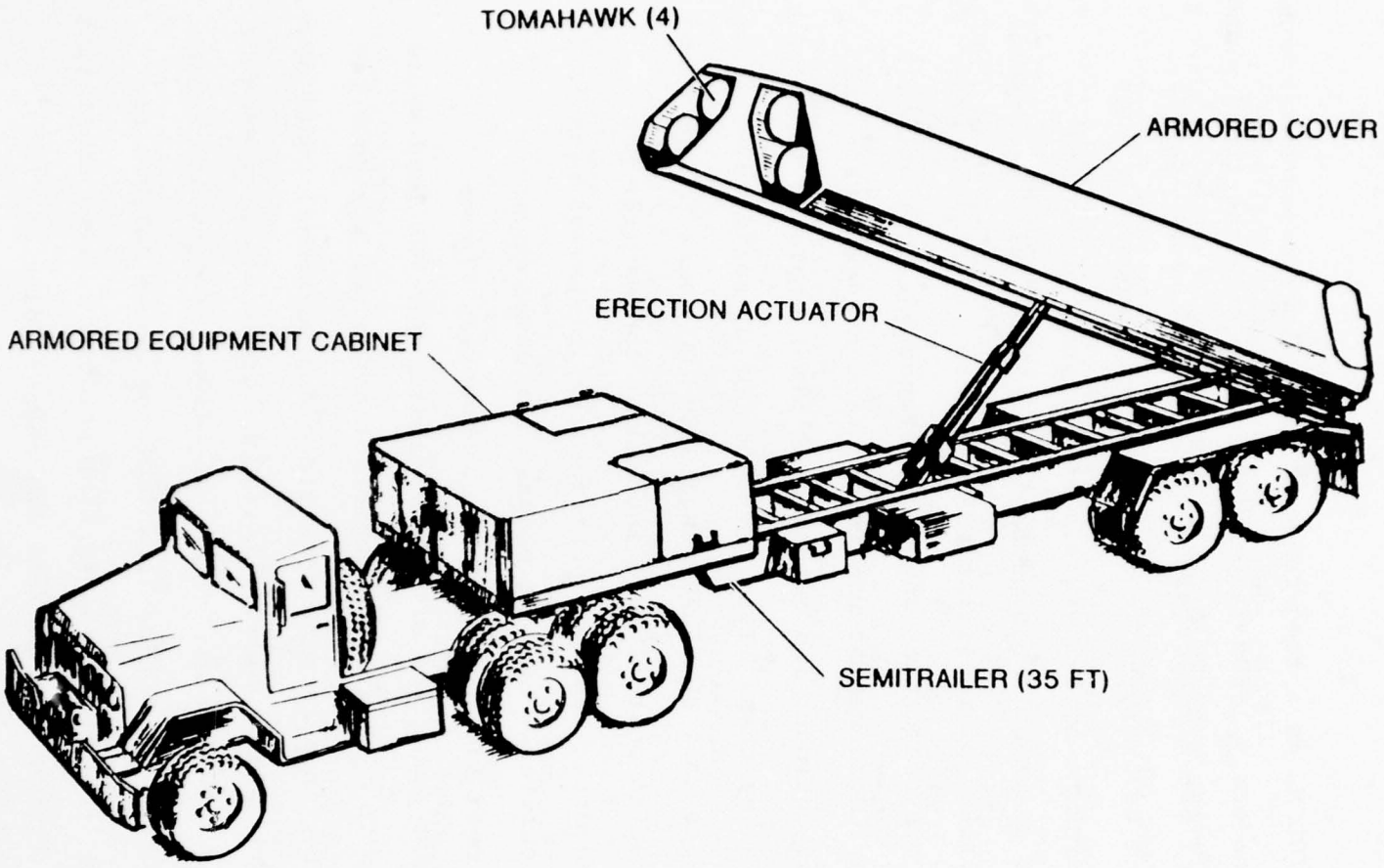
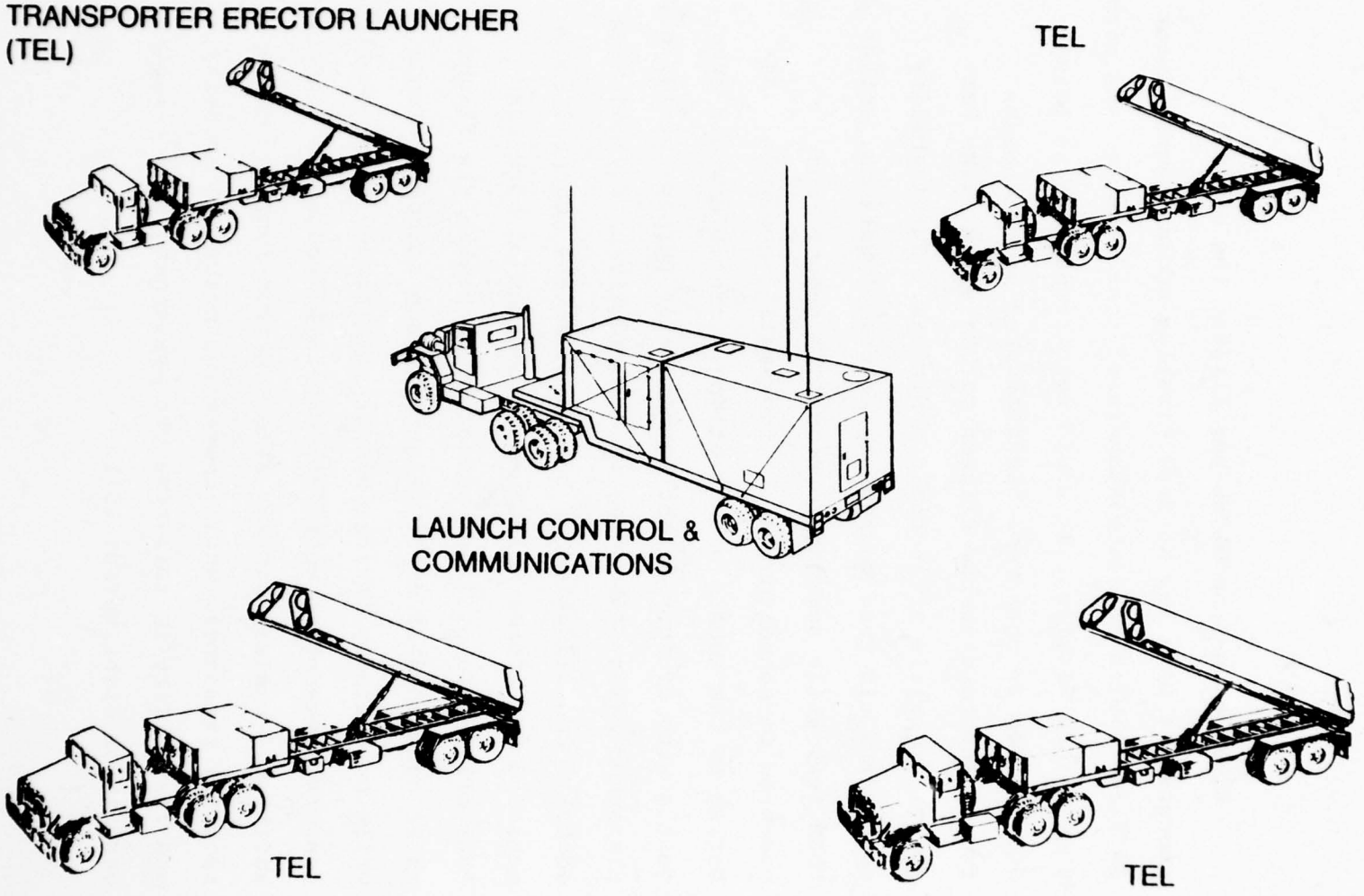


FIGURE 6-2

GLCM FLIGHT



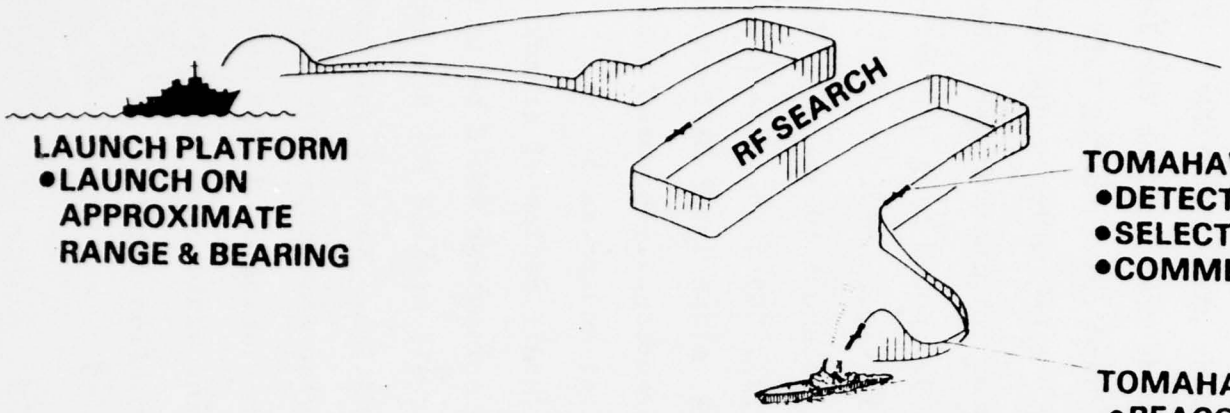
With 16 on-line GLCMs per flight, the overall procurement of a few hundred missiles would suggest about 20-30 flights with adequate numbers of test missiles and perhaps some reload missiles. It would seem reasonable to base GLCM forces in squadrons headquartered at main bases from which to disperse flights to QRA sites (like Pershing) or crisis alert field positions. Survivability concerns would tend to support several locations, rather than few, while seeking to trade off support and overhead personnel costs of "too small" squadrons. Adhering to the square organizational principle would suggest a wing of four flight squadrons at perhaps six widely dispersed bases, resulting in high survivability(and high costs). Consolidation of the headquarters overhead could be achieved by forming non-square squadrons of more than four flights (e.g., four squadrons each with six flights, three squadrons of eight flights). Such consolidation, while potentially increasing vulnerabilities to preemption, conserves peacetime costs for otherwise redundant support, additional nuclear storage site construction, and extra security personnel, while increasing peacetime security and flexibility in full-time QRA assignment (one flight per six or eight versus 25%).

SLCM programs include the Tomahawk anti-ship missile (TASM) and the Tomahawk land attack missile (TLAM). Previous plans for delivery in 1981 of the first production of a total procurement quantity of 1,082 Tomahawks[12] have been changed. Procurement plans for TLAM have been temporarily deleted, with funds now retained for 325 TASM beginning in 1981, but stretched out into the late 1980s at a low rate of production. TASM, which would need means for target acquisition, uses radar terminal guidance derived from Harpoon to deliver the 990 pound high explosive BULLPUP B warhead as shown in Figure 6-3.

Deployment of Tomahawk on about 50 ships including a few surface combatants (e.g., DD963 Spruance class destroyers) and several SSNs, might later be considered for expansion to Allied conventionally-powered submarines, supported by nearby facilities and ports or to converted Polaris SSBNs.[13] Modification of attack submarine systems to accommodate Tomahawk would be in the $400-500,000 range, or about $15 million for SSN deployment of about 130 cruise missiles. Surface ship modification, necessarily involving more extensive fire control system improvements and installation of a 22.5 ton armored box launcher on each combatant would cost about $5 million for each ship or about $75 million total.

FIGURE 6-3

TOMAHAWK ANTI-SHIP ROLE



LAUNCH PLATFORM
- **LAUNCH ON APPROXIMATE RANGE & BEARING**

TOMAHAWK
- **DETECTS SHIP**
- **SELECTS TARGET**
- **COMMENCES HOMING**

TOMAHAWK
- **REACQUIRES TARGET**
- **POPS UP**
- **HOMES WITH ACTIVE RF OR HOME-ON-JAM**

Satisfying Force Criteria

Desirable force characteristics form criteria for assessing the capability of forces to present an effective defense or deterrence when credibility of use is shown. Satisfaction of the criteria therefore measures the significant defense and deterrent value of theater cruise missile forces.

- Reduced vulnerability is achieved by surface ship mobility, submarine mobility and concealment, and GLCM hardening at rearward bases in peacetime; after alert, dispersal and camouflage increase GLCM pre-launch survivability. Survivability in flight is high due to low altitude, low radar cross section, low infrared signature, and visual toning, as well as high subsonic speed.

- Flexibility exists due to the variety of launch platforms, selective employment plans, wide range capabilities, optional warheads, and pre-plannable attacks from any direction (e.g., penetrate and maneuver to approach from the rear); ambiguity, inherent in the variants, contributes to deterrence.

- Military effectiveness is demonstrable in both the nuclear warhead hard target kill potential and the non-nuclear warhead submunition area target coverage.

- Non-provocative characteristics include long time of flight, limiting cruise missiles to retaliation versus disarming, and high overall survivability, decreasing incentives for Soviet preemption; stability is therefore enhanced.

- Allied solidarity would be demonstrated through foreign basing, arms sales, and implemented nuclear programs of cooperation; linkage to conventional and strategic forces would be retained.

- Concurrent improvements in timely target acquisition, responsive control and communications, and flexible response options for use contribute to defense and deterrence.

- Perceived credibility of use accrues from precise delivery, selective use, controllability, limited collateral damage, and affordability.

- Detente, in the form of arms control negotiations, would be supported by a clear commitment to discuss valuable U.S. theater cruise missiles in the context of Soviet peripheral attack systems which cruise missiles counter balance.

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CHAPTER VII

CONCLUSION

> ...the overriding objective of our foreign policy is to maintain U.S. interests under conditions of international peace and stability. At present, our basic interests remain intact. Perhaps the greatest immediate threat to them comes from economic and monetary forces. It would be a mistake, however, to underestimate the problems created by the military buildup of the Soviet Union. Those problems are real. They are serious. They are continuing. They could become critical--and if they do, we would regret not having started to build up our own military capability now. It may be too late if we wait much longer...where defense itself is concerned, stability should remain on a par with deterrence among our objectives.
>
> Harold Brown
> DoD Annual Report FY 1980

Support of Policy

Balancing deterrence and stability connotes a need to judge the value of acquiring militarily effective force capabilities versus the risk of exceeding the threshold threat to the Soviets which would invite early coercion, preemption, disarming attacks, or a reactive terminal arms race. In suggesting that "how much is too much" warrants equal assessment with "how much is enough." The Secretary of Defense proposes a basically conservative defense posture, "designed both to control Soviet actions and to hedge against the main uncertainties of the future."[1]

The Soviet perception of forward based cruise missiles, noted in the previous chapter, suggests the adequacy of their deterrent value. Force planning criteria important to the support of policy and advantageous characteristics of cruise missiles are shown in Table VII-1.

TABLE VII-1

THEATER CRUISE MISSILE SATISFACTION OF CRITERIA

CRITERIA	CRUISE MISSILE CHARACTERISTICS
Survivability	Low cross section and altitude, high speed, mobility, hardening, dispersal, concealment.
Flexibility	Variety of launchers, plans, range, warheads.
Effectiveness	Nuclear hard target, conventional submunitions.
Stability	Long time of flight, second strike, survivable; no incentive to preempt.
Solidarity	Basing, sales, programs of cooperation, dual capable link, strategic coupling.
Affordability	Relatively cheap - costly to defense, causes Soviet costs.
Credibility	Precise, selective use, control, low collateral damage.
Arms Control	SALT II consistent, valuable.
Balance	Theater offset to SS-20, Backfire, etc.

Satisfaction of these criteria by GLCM and SLCM indicates significant support of defense and deterrent policies, while offering potential arms control initiatives supporting detente. By presenting a credible, survivable, and militarily effective means of military power, Soviet theater encroachment can better be deterred.

> Deterrence is usually seen as the product of several conditions. We must obviously be able to communicate a message to the other side about the price it will have to pay for attempting to achieve an objective unacceptable to us. We must have the military capabilities necessary to exact the payment (at a cost acceptable to ourselves), whether by denying our opponent his objectives, by charging him an excessive price for achieving them, or by some combination of the two. We must have the plans and the readiness necessary to demonstrate that we can deliver on our "message." We must be sure there is no way for the opponent to eliminate our deterrent capability. At the same time, our deterrent message must have some degree of credibility. That is to say, both we and our opponent must believe there is a real probability that we will indeed perform the promised action, if required.[2]

Contributions to stability are inherent in survivability, precision, long time of flight (precludes disarming capabilities), and implicit restraint in use. Clear enunciation of the non-provocative nature of theater cruise missiles, of projected non-nuclear capabilities, and of commitment to the control of escalation even during conflict must have the effect of alleviating unfounded fears that wars will inevitably escalate to strategic nuclear

exchanges once the nuclear firebreak is crossed. Discrimination, control, and restraint contribute to the goal of terminating a conflict on suitable terms. In sum, a relatively invulnerable, very flexible, forward yet survivable, and non-provocative second strike system promotes deterrence and stability, therefore supporting the security of vital national interests and peace.

Major Issues

Three major issues concern theater cruise missiles.

- First, arms control, in the military sphere of detente, involves ceilings on cruise missiles. SALT II limits long-range cruise missiles, but with ambiguities concerning non-circumvention, verification, and ill-defined post-1981 Treaty terms for long-range ground and sea launched cruise missiles. MBFR could set implicit missile launcher ceilings in part of Western Europe. SALT III most likely will address long-range theater systems, seeking to establish ceilings on U.S., Allied, and Soviet non-strategic weapons.

- Second, the procurement of cruise missiles will be based, in large part, on the relative cost-effectiveness of Air Force GLCM, Navy SLCM, dual-capable aircraft, and other missiles, e.g., Pershing II and a new MRBM.

- Third, participation in basing and ownership will involve complex assessment of Allied perceptions, likely

Soviet reactions, and weapons system value.

Recommendations

There appear to be several interim actions in the areas of procurement, participation, and publicity associated with the major issues, including:

- Setting a floor on GLCM procurement funds.
- Reinstating SLCM land attack purchase.
- Increasing the number and type of Navy platforms planned for SLCM.
- Confirming GLCM basing details with NATO Allies.
- Negotiating sales of non-nuclear cruise missile hardware.
- Establishing nuclear programs of cooperation with NATO Allies.
- Advertising U.S. intent to sell cruise missiles and to base USAF GLCM in Europe.
- Publicizing the non-provocative nature of these survivable, effective, and non-first strike weapons.
- Demonstrating commitment to a stable balance of long-range theater systems in support of U.S. and Allied policies and vital interests.

APPENDIX A

TOMAHAWK CRUISE MISSILE

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Technological Evolution

Cruise missiles, as a type of nonpiloted aircraft, have existed as reconnaissance and weapons systems for over sixty years. Weapons systems evolving from the German V-1 (Buzz Bomb) technology of World War II were not significantly different in accuracy or size, although the nuclear era provided new arming options for U.S. systems such as Regulus, Snark, Mace, and Hounddog.[1] Advances in technology particularly adaptable to the development of smaller, air breathing, aerodynamic missiles in the 1970's were related to guidance, propulsion, and arming.[2]

-- Guidance: Microcircuitry technology developed densities of about a million bipolar, transistor equivalent devices per square centimeter on substrate only 250 microns thick. This allows extensive digital computer logic capabilities, with memory storage capacities of about 100 million bits per cubic centimeter. Concurrent advances in production of digitized pseudo-radar map data from satellite data and airborne radar altimeters (vertical resolution to 1 foot; horizontal to 10 feet square) suggested a correlation scheme for guidance. Terminal guidance systems were also available in very small packages with high resolution.

-- Propulsion design of small, high bypass ratio turbojet and turbofan engines led to thrust to weight ratios of about 4:1 for 100-150 pound engines. Improved hydrocarbon fuels, yielding 10-20% better performance than standard fuels

(e.g., kerosene, JP-4), and boron-hydrides (about 50% better than standard) contributed to engine performance.

-- Arming with improved conventional munitions grew attractive during the Viet Nam War, with proven sub munitions designs being followed by an even more lethal generations in the early 1970's. Nuclear warhead design had reached one kiloton of yield per pound of warhead weight for relatively small warheads, allowing 200 KT in a 200 pound package.

Tomahawk[3]

The Navy sea-launched cruise missile (SCM) program and the redirected Air Force subsonic cruise armed decoy (SCAD) program, taking advantage of evolving technologies, were placed under a Joint Cruise Missile Project Office following extensive Department of Defense/National Security Council discussion and subsequent decisions. The association of the General Dynamics developed "Tomahawk" with only the sea-launched cruise missile (SLCM) camouflages the fact that essentially the same missile can be air or ground launched (ALCM and GLCM). The SCAD program, essentially cancelled but traceable into the joint program, evolved into a Boeing proposed strategic ALCM. Theater cruise missile variants, long or short range, could use the General Dynamics missile (shown on the following page in Figure A-1) and so, perhaps inappropriately from a Navy point of view, they are referred to as Tomahawks. Tomahawk characteristics are shown in Table A-1.

FIGURE A-1

TOMAHAWK MISSILE



TABLE A-1

TOMAHAWK CHARACTERISTICS

Diameter	21 inches
Length	20.5 feet (with booster)
Weight	3200 pounds (with booster)
Engine	Turbofan[a] (Williams Research)
Warhead	Nuclear[b] Conventional (1000 pounds)
Cruise Speed	High subsonic[c]
Range	2000 nautical miles (shorter for conventionally armed variant)[d]
Guidance	Inertial with Terrain Contour Matching (TERCOM)
Accuracy	High accuracy[e]
Altitude	20-100 meters

a) Weight 60kg/130 pounds, 600 pounds thrust.

b) W-80, noted as 150-200 KT, with Category F limited try permissive action link (6 digit, 2 person control lock), weighting about 270 pounds.

c) Cited in unofficial references as 691 Km per hour, Mach 0.8, Mach 0.7 cruise and Mach 0.85 max, 880 Km per hour, 725-885 Km per hour or 450-550 mph, and 550 mph.

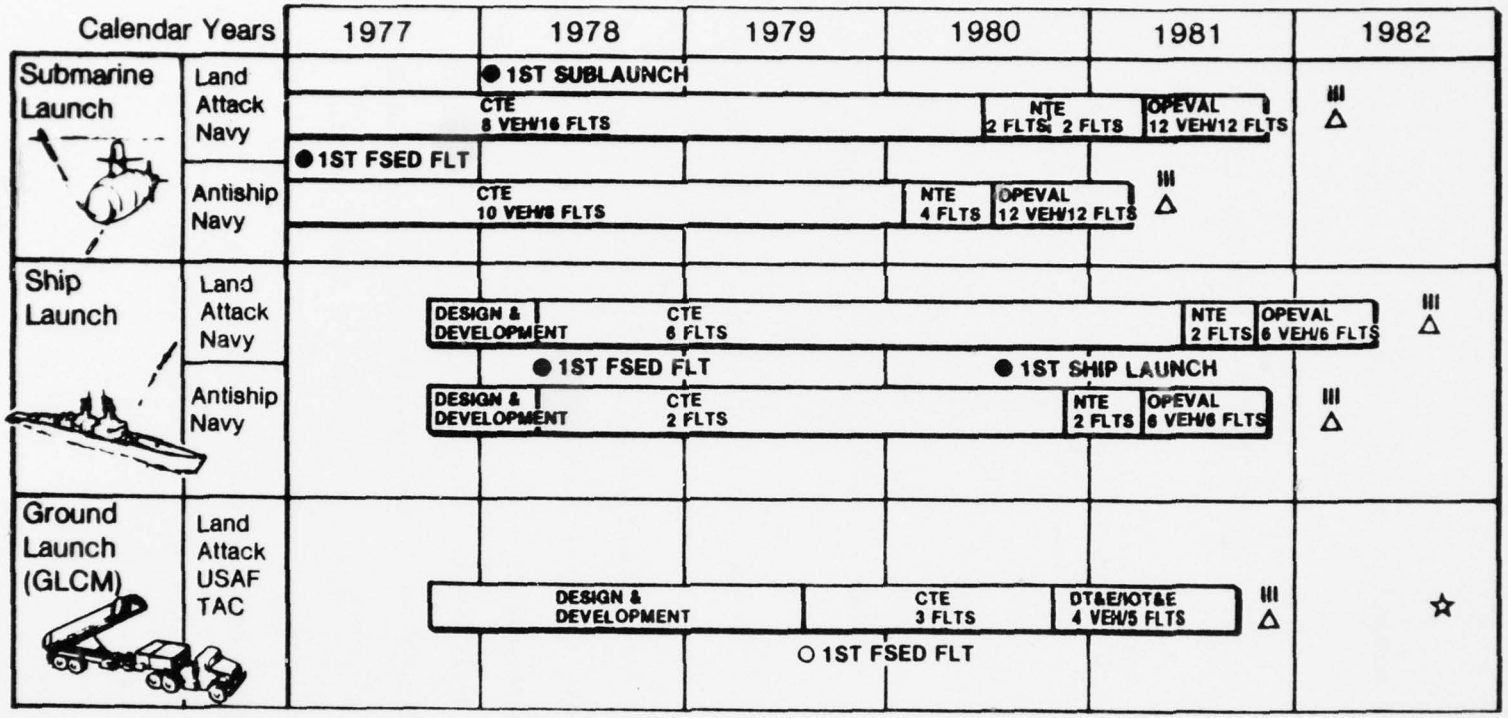
d) Noted as about 300-550 miles for conventionally armed and 2000-5000 Km maximum for nuclear armed.

e) Cited in the zone of 12 to 50 plus meters with TERCOM; perhaps 3 meters with terminal guidance Scene Matching Area Correlator (SMAC).

The engineering development program for GLCM and the two SLCM Tomahawk variants is shown in Figure A-2.

FIGURE A-2

ENGINEERING DEVELOPMENT PROGRAM



Cruise missile program costs[5] are shown in Table A-2.

TABLE A-2

CRUISE MISSILE PROGRAM COSTS
($ millions)

Program	Authorized Through FY79	Proposed FY80-84	Projected Post FY84	Total Cost	Units
ALCM	999	2396	789	4184	3000+
GLCM	93	921	513	1627	696
SLCM	655	987	933	2676	325
TOTAL	1747	4304	2235	8487	

Many sunk RDT&E costs applicable to all programs were originally funded in the SCM/SCLM program or the SCAD/ALCM program. They are not appropriately post-allocated to the current programs. The resultant unit costs derivable from the SAR are therefore skewed to some extent. ALCM enjoys the additional advantage of a larger build over which to amortize overall program costs, but is "burdened" with two parallel designs pending a procurement decision in 1980. A subsequent decision to plan at this time for only the antiship SLCM exagerates the projected procurement unit cost of that system. A subsequent decision to plan for a land attack version of the SLCM would lower unit costs.

The ground launched cruise missile portion of the joint program is shown in Table A-3, while sea launched cruise missile costs are shown in Table A-4.

TABLE A-3

GLCM COSTS
($ millions)

	Thru FY79	FY80	FY81	FY82	FY83	FY84	TOTAL	
Units	-	-	45	120	120	120	696	[a]
Procurement	20.2	25	149.1	266.6	232.3	211.7	1427.3	
Spares	-	-	1.8	4.8	4.8	4.8	30.6	
RDT&E	51.7	44.1	49.9	16.9	5.8	-	168.4	
MILCON	-	-	-	19	-	39.8	77.3	[b]
TOTAL ACQUISITION	71.9	69.1	200.8	307.3	242.9	256.3	1703.6	[c]

[a] As of May 1979; subsequently proposed to decrease.

[b] Could increase, dependent on basing and operational concept decisions, perhaps to $200 million.

[c] Excludes potential military construction increases and Department of Energy costs.

TABLE A-4

SLCM COSTS
($ millions)

	Thru FY79	FY80	FY81	FY82	FY83	FY84	TOTAL
Units	-	-	24	28	30	40	325
Procurement	-	3.3	72.6	65.6	68.5	81	491.7
Spares	-	-	4.2	4.9	5.3	7.0	31.3
RDT&E	554.5	103.4	43.1	34.1	14.9	-	888.4[a]
MILCON	-	0.5	-	-	-	-	0.5
TOTAL ACQUISITION	554.5	107.2	119.9	104.6	88.7	88	1411.9

[a]Includes early benefits for ALCM and GLCM, as well as surface ship platform and antiship guidance RDT&E.

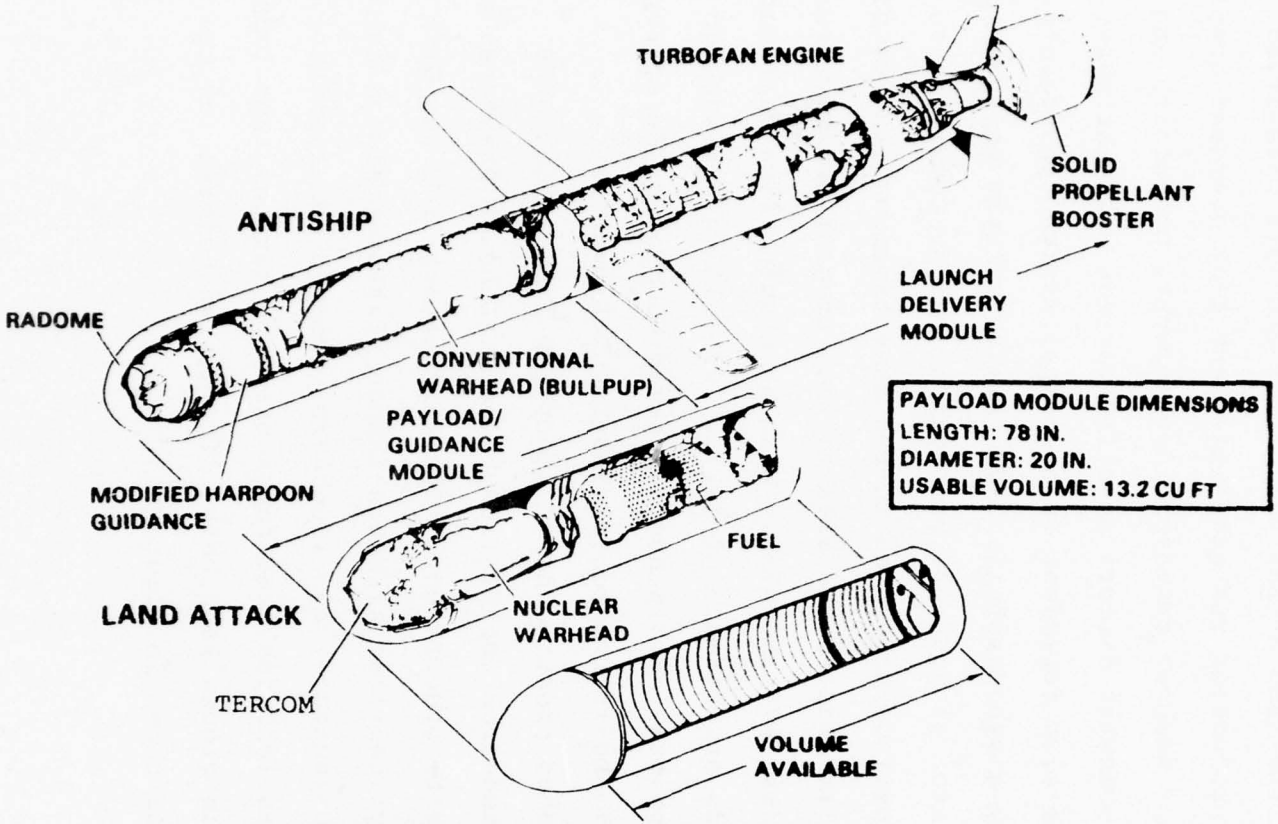
Procurement costs for additional cruise missiles are dependent on quantity and the results of the 1979 ALCM fly off between the Boeing AGM-86B and the General Dynamics AGM-109 competing designs. If the General Dynamics Tomahawk-based ALCM design is selected, commonality of the three systems significantly reduces the unit price relative to a diverse Boeing ALCM, Tomahawk SLCM/GLCM selection. Current procurement unit costs for GLCM ($2 million) and SLCM ($1.5 million) for the 1021 currently planned missiles could be driven downward by increasing the total buy through a common ALCM program, additional SLCM, or allied buys.

Department of Energy costs for nuclear warheads for GLCM and the land attack variant of SLCM are classified. The low production run quantities and high overhead costs of nuclear weapons research, development, production and testing somewhat distort specific warhead cost estimates, which are also dependent on technical design constraints. In testimony given March 14, 1974, Alain C. Enthoven suggested an indicator of $500,000 per weapon. Joint Committee on Atomic Energy Hearings conducted in the same timeframe indicated a higher unit cost in the $944 million program for new artillery projectiles (W74 and W75). With an ensuing five years of inflation, an estimate of $0.7 - 1.0 million per warhead might be appropriate. For a nuclear armed GLCM or SLCM, the overall cost would be increased outside the DoD budget.

Planned procurement of about 600 land attack SLCM was deleted from the FY 1980 budget, although pressures exist to reinstate procurement. The land attack SLCM and GLCM are virtually identical although launch platform related hardware varies for surface ship launchers (armored box launcher), submarines (encapsulated for subsurface torpedo tube launch), and mobile ground launchers. The design concept for the missile is shown in Figure A-3.

FIGURE A-3

TOMAHAWK DESIGN CONCEPT

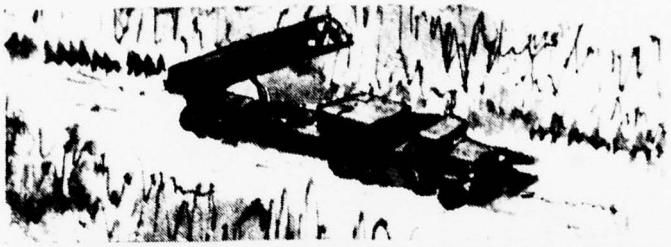


Tomahawk is adapted to varied missions by modifying the payload module

The various launch platforms, shown in Figure A-4, can fire either the nuclear or high explosive armed cruise missile, as well as any other variant developed to fit the available payload space.

FIGURE A-4

LAUNCHERS



GROUND LAUNCH — WITH ALUMINUM CANISTER



SHIP LAUNCH — WITH ALUMINUM CANISTER



SUB LAUNCH — WITH STEEL CAPSULE

Figures A-5 through A-8 indicate possible GLCM missions, surface ship platforms, submarine concept, and the overall system flexibility.

Guidance and Accuracy

The terminal guidance set shown in Figure A-3 with the conventional unitary warhead is a modified Harpoon antiship missile radar homing device.
which is basically an electro-optical device. The land attack cruise missile guidance set consists of a radar altimeter, an inertial guidance platform, and a terrain contour matching (TERCOM) microprocessor. Intrinsic drift of inertial platforms would provide insufficient accuracy, so the terrain following radar (for very low altitude flight to the target) provides a second function -- input to be compared with onboard stored digital maps. This TERCOM assisted inertial navigation system (TAINS)is updated to correct the missile position during flight to avoid defenses and to increase terminal accuracy. From data prepared by Defense Mapping Agency, TERCOM maps of digital elevations of small cells within a much larger field are prepared as shown in Figure A-9.[6] Several sets of data, representing sequential update fields along the preplanned

FIGURE A-5

GROUND LAUNCH MISSIONS

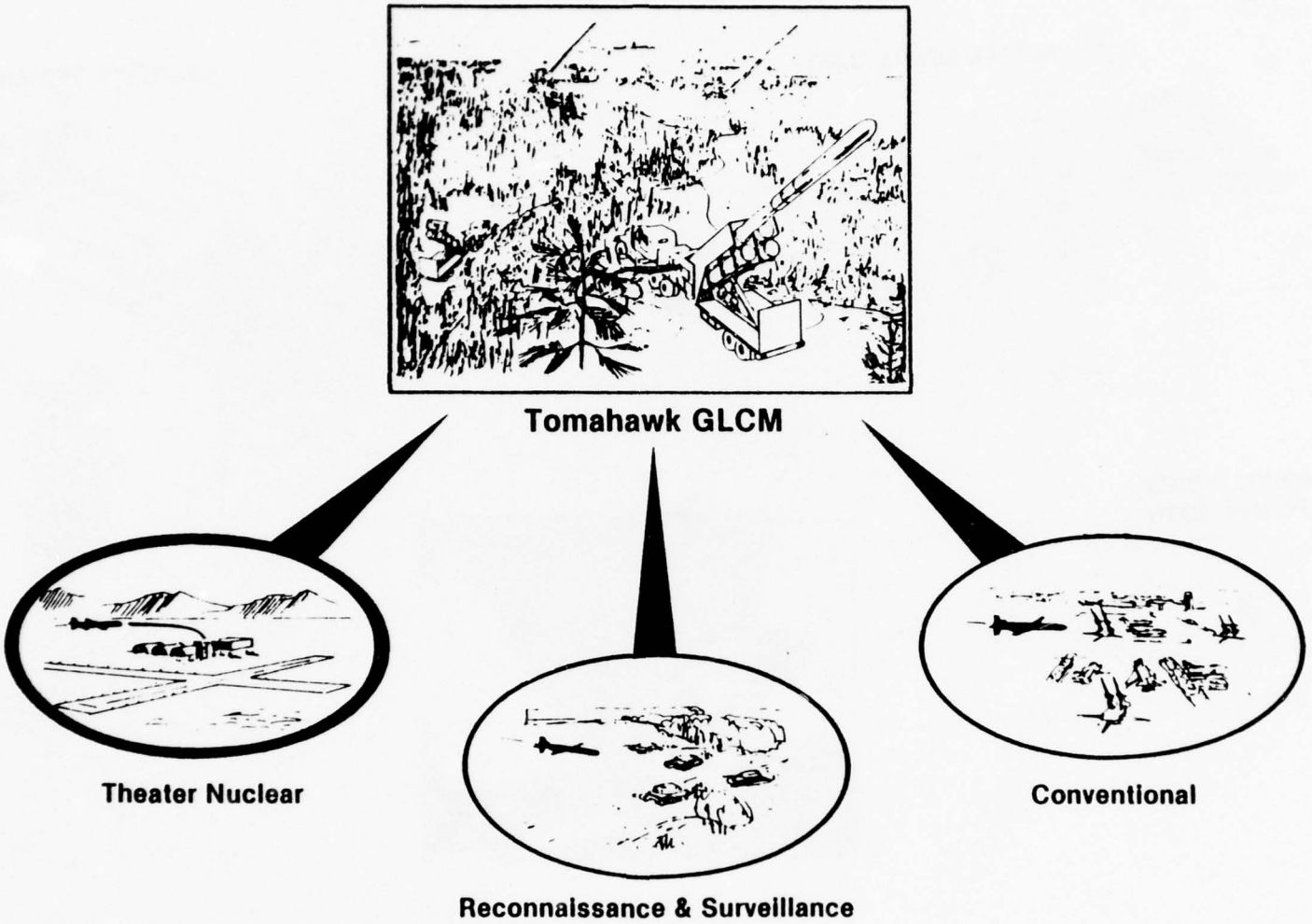


FIGURE A-6

SURFACE SHIP INSTALLATIONS

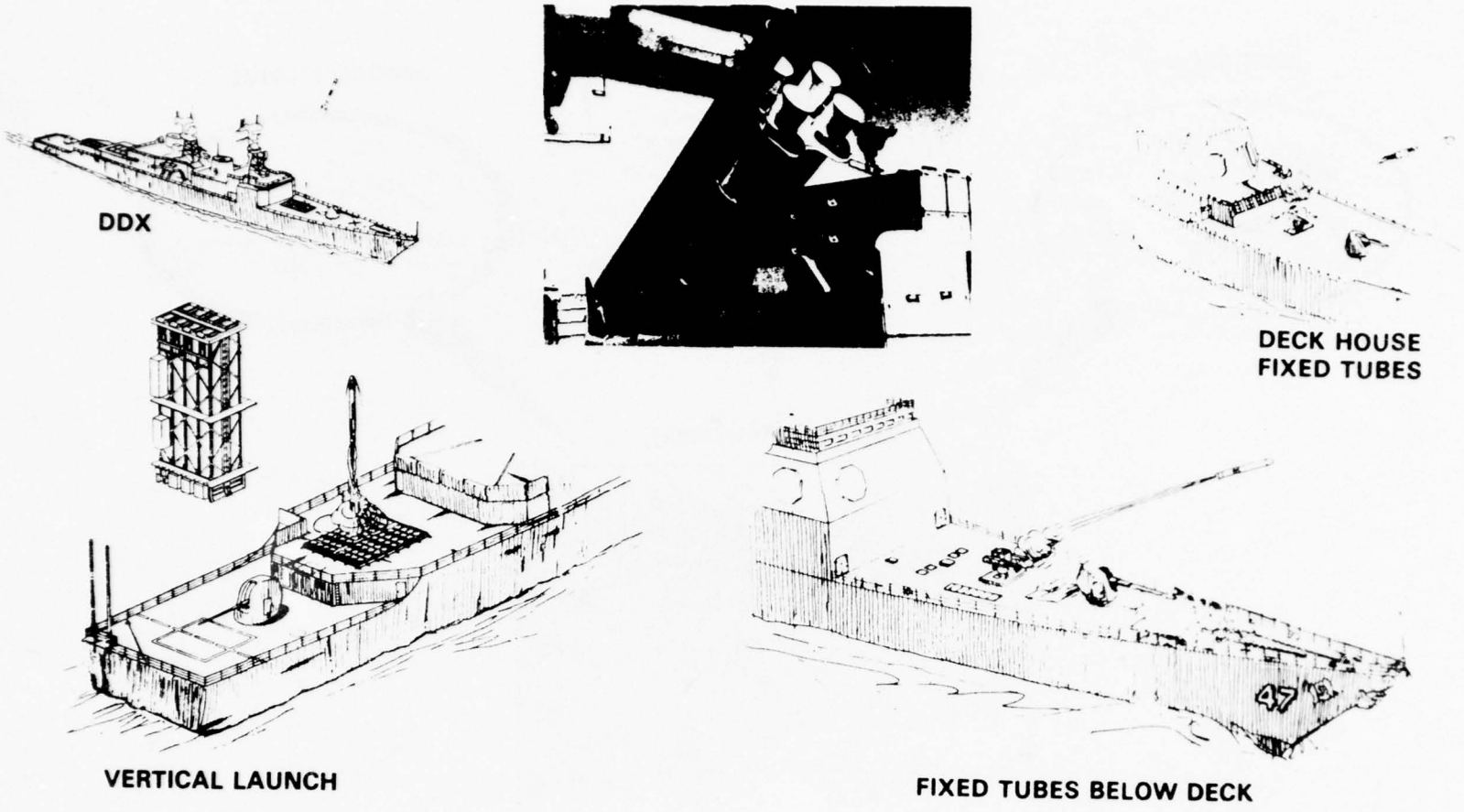


FIGURE A-7

SUBMARINE-LAUNCHED TOMAHAWK

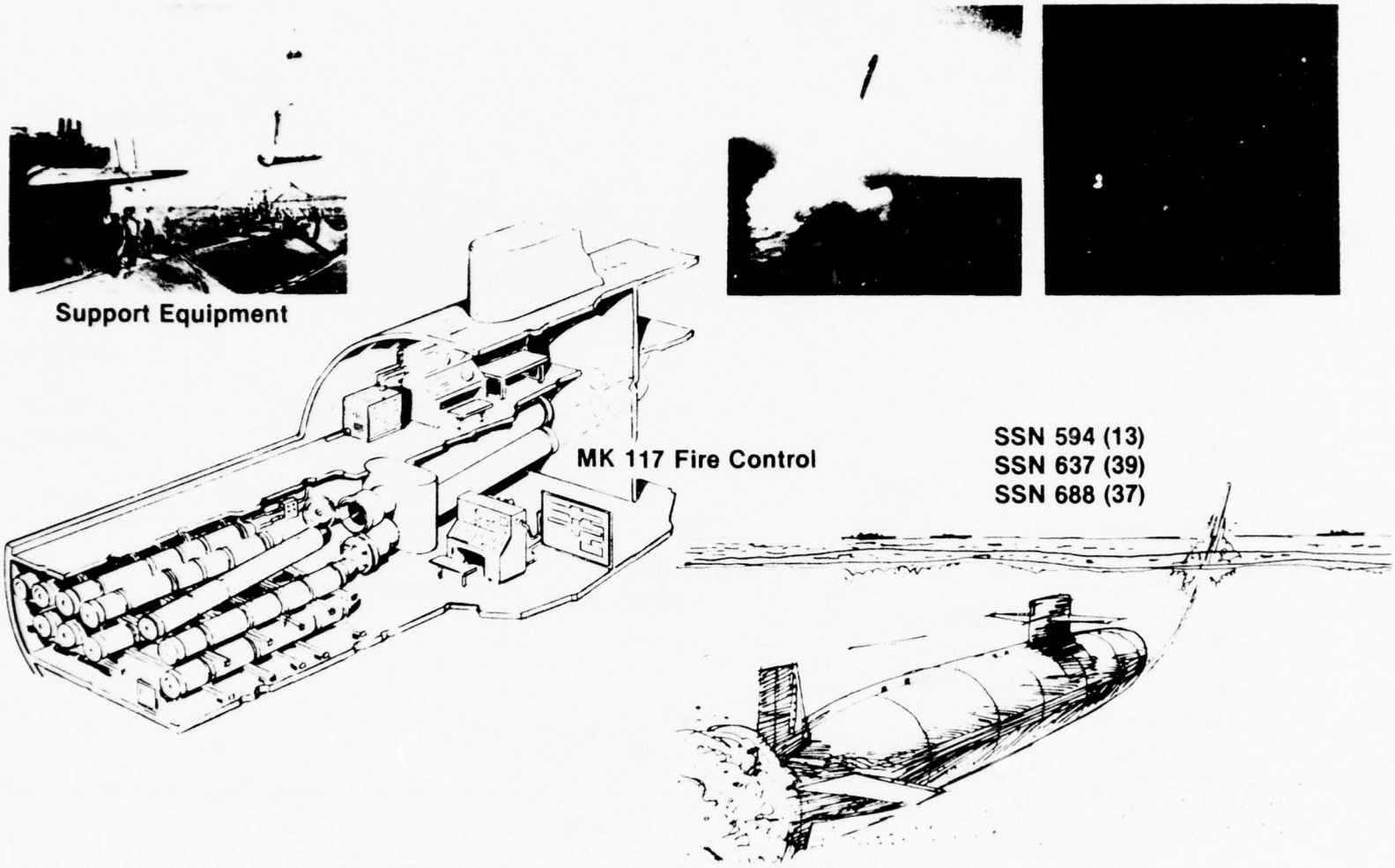


FIGURE A-8

MISSION & LAUNCH PLATFORM FLEXIBILITY

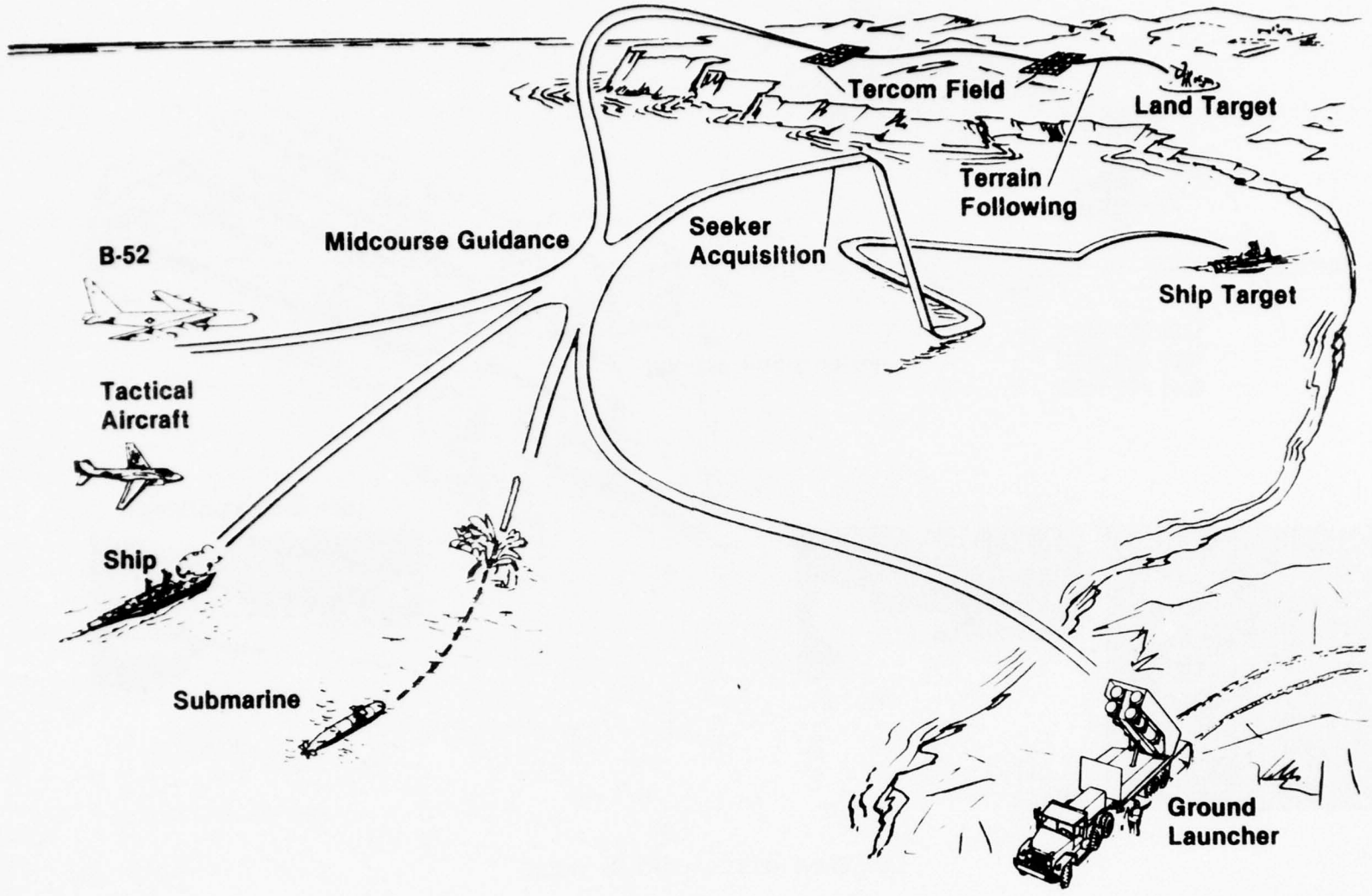
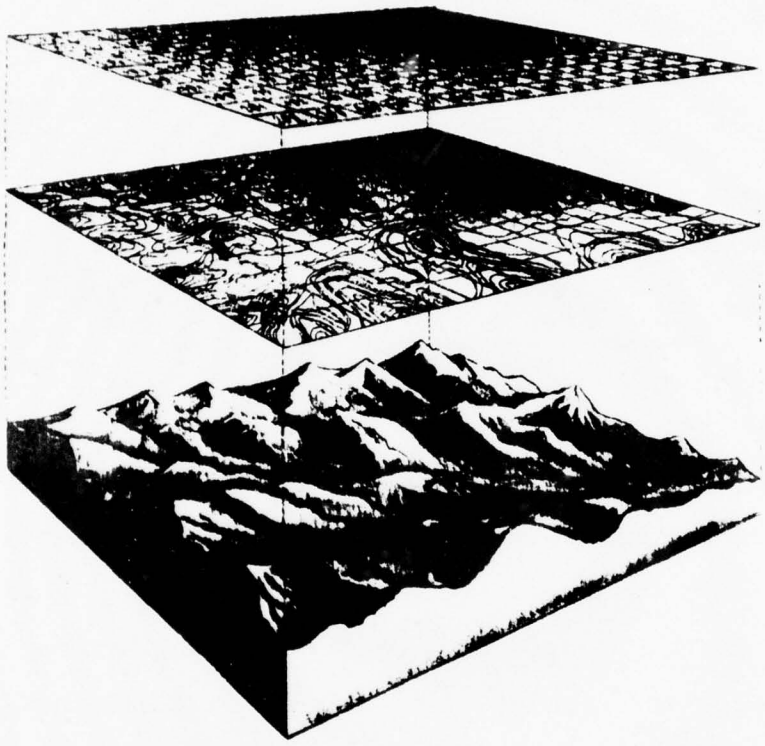


FIGURE A-9

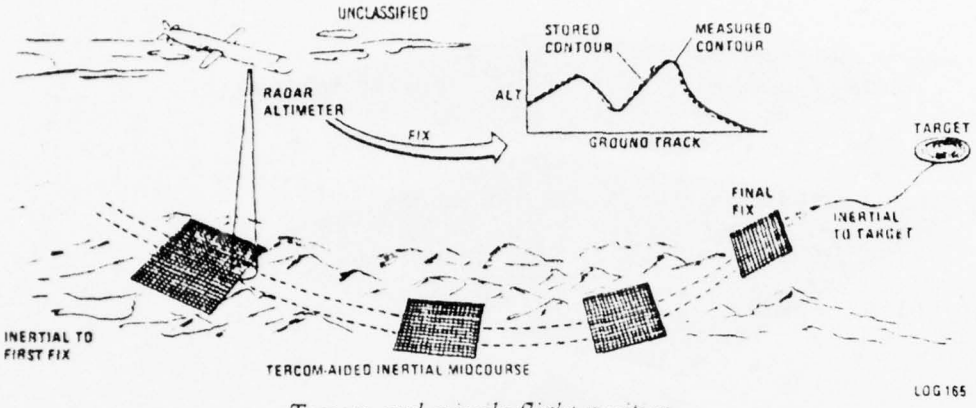
DIGITAL TERRAIN MAP



flight path are loaded into the guidance set. The altimeter real time data is then best-matched with stored data to generate corrective steering commands to guide the missile as shown in Figure A-10.

FIGURE A-10

FLIGHT PATH UPDATES



Tercom and missile flight position.

Accuracy is improved by diminishing both the final fix cell size and the remaining distance to the target. The final fix should be adequately close to the target -- far enough away to allow correction of flight path, but not so far as to allow inertial platform drift. Accuracy in distance should then be at least the same as cell dimension, perhaps ½ the cell size in practice.[7] Cell size, or resolution, could theoretically be 10 meters, but practically it is limited to perhaps 100 meters, implying about 50 meters accuracy.[8] High accuracy, even with lower yield nuclear warheads, is the principle factor in killing hard targets. The kill factor,

K, varies directly with yield to the 2/3 power (equivalent megatonage relationship) and inversely with miss distance to the power of 2 -- by halving the miss distance (getting more accurate), K improves by a factor of 4. The reported kill probability of Tomahawk and two strategic missiles against relatively hard targets is shown in Table A-5.[9]

TABLE A-5
KILL PROBABILITY

	200 psi Target	1000 psi Target
Tomahawk (200 Kt)	0.90	0.85
Minuteman III (350 Kt MK 12A)	0.76	0.20
Poseidon	0.71	0.10

Inertial platform drift, due to gravity anomalies and electro-mechanical imprecision, is not so critical for short times of flight. But subsonic cruise missile flight times necessitate updates, such as TERCOM, even though the Tomahawk inertial drift is less than one-half mile per hour.[10] By updating frequently (perhaps every 150 miles) and using decreasing grid sizes (large initial grid, final fix grid size in the range of 200 feet), accuracy becomes almost precise.[11] TERCOM could then allow a circular error probable (CEP) on the order of 40 feet and "...new technologies

associated with the cruise missile's guidance package hold promise to yield CEPs of less than ten feet..." with a scene matching area correlator (SMAC).[12]

Conventional Warhead Options

Great accuracy after a long flight, demonstrated by Tomahawk on January 29, 1977, March 19, 1978, and May 26, 1978, showed SMAC to be sufficiently accurate to allow precise laydown of improved conventional airfield attack munitions.[13] In commenting on a film of the May 26 flight, Secretary Brown noted:

> ... a potential conventional use of cruise missiles shows that not only the terrain matching capability ... does very well at giving you accuracies in the hundreds of feet, but that we have further terminal guidance systems which match pictures in effect and are able to give accuracies much better than that. ... I wouldn't say whether it was ten feet or five feet or twenty feet, it's feet, and that accuracy was attained after a guided flight, a self-contained guided flight of 800 miles. That's a remarkable achievement and I think it says a good deal about the potential utility of this kind of system in conventional warheads - in conventional warfare.[14]

Given the 13 cubic feet of payload space, a wide variety of munitions in the 1000 pound class (like BULLPUP) could be carried, as shown in Table A-6.

TABLE A-6

IMPROVED CONVENTIONAL MUNITIONS[15]

Submunition	Type	Approximate Weight (LB)	Approximate Number In 1000 Pound Payload
M-42	Dual Purpose Frag and Shaped Charge	0.4	2500
BLU-61	Antimateriel Frag, Incendiary	2.7	400
BLU-63B/ M-74	Frag (14 Grain) Incendiary	0.9	1000
BLU-73	Fuel Air Explosive	90	10
BLU-81	Frag, Cratering Mine	70	15
BLU-87/ BLU-49B	Frag, Incendiary	14	70
BLU-97B	Combined Effects Frag, Incendiary	3.5	260
MK-118	Frag	1.3	700
Martin Dual Charge	Shaped, Penetrating Second Explosive	16	40[a]
Hard Structure Munition	Shaped Charge	13	70
Cluster Air-field Denial Munition	Shaped Charge	45	20
Bullpup	Frag	990	1

[a]Space constrained.

All have anti-materiel capabilities (except the BLU-73) and can penetrate unarmored vehicles, radar shelters, and unprotected buildings. For example, the improved BLU-63/B, with better dispersing fragments and a pyroforic, secondary ignition additive, could be used in a two missile attack (about 2000 bomblets) to achieve SAM system kills of 0.6 to 0.8. The 260 14-grain fragments, with initial velocities of 4500-4900 feet per second, from each of the BLU-63B bomblets cover a large lethal area.

Airfield attack by conventionally armed cruise missiles could use submunition warheads containing BLU-81 (Grasshopper) mines, cluster airfield denial munitions (CADM), or Martin designed dual stage munitions. Even with a low CEP, killing a 240' wide runway with great certainty might require more than one shot, as shown in Table A-7.

TABLE A-7

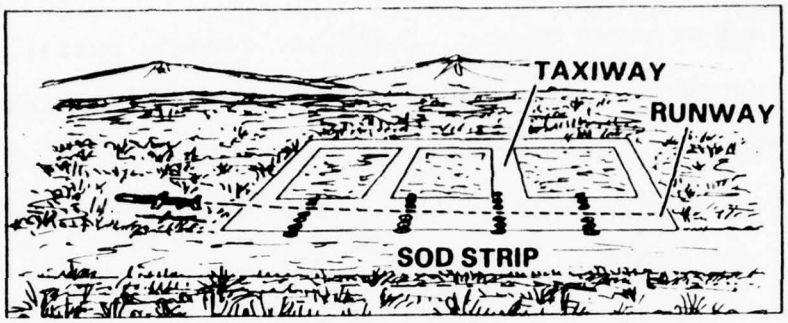
RUNWAY KILL

MUNITION	BLU-81	CADM	DUAL
Weight (Lb)	70	45	16
Load (Approx.)	15	20	40
Runway SSPK	0.5	0.3	0.6

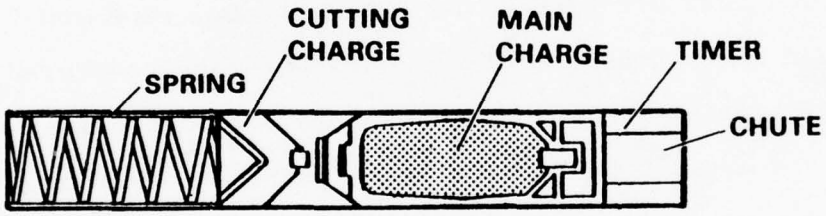
The delivery technique for the dual charge hard structure munition is shown in Figure A-11. This is similar to the May 26, 1978, demonstrated approach.

FIGURE A-11

RUNWAY ATTACK



- DUAL CHARGE HSM (SUBSCALE)
  (3.35 IN. x 13.7 IN., 13 LB)



SEQUENCE

- EJECT RADIALLY
- DEPLOY CHUTE
- INCREASE FLIGHT PATH ANGLE



Two cruise missiles could be used in a 10-30 second pop-up attack to achieve good target effect while preserving low altitude, survivable flight until strike. Runway cratering requiring a few hours repair time might deserve multiple sorties, perhaps two flights of two cruise missiles separated by 30-60 minutes. This delay raises the possibility of damaging repair equipment in the second attack. The delay also takes advantage of post-attack defense relaxation to increase penetration probability of the second attack.

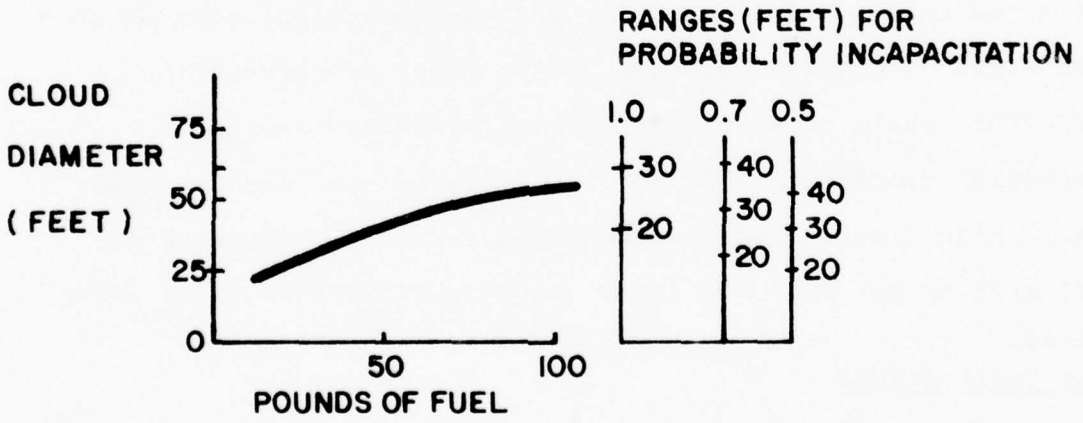
For alternative effects, a mix of attacking warheads might be attractive. If one of the four attacking missiles used about ten fuel air explosive (FAE) charges, each containing about sixty pounds of fuel, anti-personnel overpressure incapacitating effects might cover over 10,000 square feet of non-contiguous area. The disruptive effect of scattered anti-personnel FAE (or bomblet) munitions could significantly delay runway repair.

Fuel air explosives rely on overpressure for effect. Peak pressure, primarily a function of the fuel used, is 300 plus pounds per square inch. Duration, key to most damage effectiveness, is a function of cloud thickness (volume of fuel and expansion in the target area). For antipersonnel use, a 5' thick cloud (probably the minimum) requires about 30 pounds of fuel; the area covered would be over 700 square feet. If personnel are in buildings or bunkers, overpressure is still effective for the 30 pound fuel air explosive with probabilities of kill ranging from 1.0 at 15 feet range to 0.5 at 25 feet.

Weaponizing FAE warheads adds some, but not much, weight. Delayed action detonation (to allow cloud spreading after bursting and before explosion), a small fuze, and packaging should add about 10 pounds to the 30-50 pound fuel weight classes; for the BLU-73, sixty plus pounds of fuel are contained. Figure A-12 shown approximate FAE cloud sizes and incapacitating effects. Note that one cruise missile with ten BLU-73s could optimally achieve an incapacitating probability of 0.7 over an area of about 7000 square feet; if armed with twenty FAE charges, each of half the BLU-73 fuel capacity, the same incapitation could cover almost 8000 square feet.

FIGURE A-12

FUEL AIR EXPLOSIVE EFFECTS



A general purpose bomb or unitary warhead in the 250 pound class will produce spalling on the inside of a 5' concrete slab; it will blow through almost 4' of concrete. A 500 pound bomb would spall a 6½' slab and blow through 4½' of concrete. Building damage radius for light industrial concrete weight bearing walls would be about 75' to 100' (extensive repair criteria) for 250 to 500 pound bombs or warheads. The 990 pound unitary high explosive warhead (modified BULLPUP B) might have a damage radius approaching 200 feet for light, unarmored structures (e.g., electronics shelters). Limited radii of effects for unitary and FAE warheads suggest restricting procurement to cluster munitions.

Cluster bomblets, of the type noted in Table A-6, packaged into cruise missile munitions payloads could eventually cost a few thousand dollars each; FAE warheads might cost about $2000 each.[16] Unitary warheads are probably producable for $1500-2000, while nuclear warhead cost estimates (noted previously) range from $500,000 to $1 million for each warhead.[17] Total cruise missile procurement costs are in the neighborhood of $1 million per copy for large quantity production runs, less warhead.

Range Implications

The choice of arming implied above must recognize the tradeoff of payload for fuel. Comparison of two variants is shown in Table A-8.[18]

TABLE A-8

CRUISE MISSILE WEIGHTS (LB)

	Nuclear Armed	High Explosive Armed
Payload		
Guidance Set	100[a]	210[b]
Warhead	270	1000
Common Hardware		
Air Frame	800	800
Booster	655	655
Engine	130	130
Subtotal (Without Fuel)	1955	2795
Total Weight	3180	3180
Fuel Weight	1225	385
Resultant Range (Km)[c]		
Low All The Way	2000	630[d]
High Approach, Low Attack	3000	940[d]

[a] TERCOM

[b] TERCOM and SMAC

[c] Figure B-1 p. 129, shows the rang -payload tradeoff.

[d] Calculated (Fuel ratio times nuclear armed missile range)

Other range tradeoffs include fuel type, as noted previously, attack profile, and cruise speed. Highly improved hydrocarbon fuels (e.g., JP-9) produce 20% increases in range compared with standard commercial fuels (e.g., JP-4 or -5); even more exotic boron-hydride fuels (e.g., Shelldyne H) allow 40-50% increases in range.

Range-speed tradeoffs vary in the neighborhood of ± 10% per 0.1 Mach, with higher (still subsonic) speeds burning fuel disproportionately more rapidly and, therefore, running out sooner. If the cruise speed is taken as Mach 0.7,[19] increasing cruise speed to Mach 0.8 could decrease range about 12%, while slowing to Mach 0.6 could increase range about 9%.

Attack profile is a simpler method of trading off range. If the first half of the "stretched" range is (more efficiently) flown at high altitude, the remaining half at tree top level, overall range can be increased 50% compared with a low all the way profile.[20]

Summary

The Tomahawk cruise missile is a versatile weapon system, with options for long or short range; highly effective conventional or nuclear warheads; and ground, surface, or submarine launch platforms. By taking advantage of evolving technologies, it has small physical size and radar cross section, high subsonic speed, low altitude terrain avoidance flight path, and high accuracy.

APPENDIX B

ARMS CONTROL ASPECTS

DETENTE AND ARMS CONTROL

> This proof of mutual confidence and perfect conformity in political views would leave much to be desired if it was not followed by a more effective and a more general measure... this convincing and decisive measure would have to consist in a simultaneous reduction of the armed forces of every kind...our united efforts will succeed, I hope, in effecting jointly... the reduction of the armed forces of every kind, the maintenance of which on a war footing weakens the credit of the existing treaties and cannot but be burdensome to all nations. [1]

This early Russian arms control initiative, stressing cooperation in the face of competition, sought to ease defense expenses by reducing potential external threats. Similar motivations for disarmament or limitation of forces and weapons have continued to the present. As weapons have become technologically more advanced, arms control measures are increasingly more detailed. Newer systems, such as submarines and aircraft delivered ordnance, developed in the late nineteenth century, were generally addressed prior to their deployment.[2]

Past and present arms control proposals have often generated emotional debates and compromises in varying degrees; however, the intensity of recent arms limitation debates exceeds all past performances. Additonally, as weapon technology has become more complex, the debates have become primarily technical, often glossing over critical strategic political aspects.

A recent collection of more philosophical views, contained in the Winter 1979 Washington Quarterly as "The Great SALT Debate," deals with a broader range of policy issues, many of which had previously received disproportionately slight attention. The following focus on primarily technical aspects attempts to avoid such topics as the arms race, stability,or equity, all of which are strategically vital, but broader than topics specifically addressing cruise missile aspects.

Current arms control activities include the Strategic Arms Limitation Talks (SALT) and negotiations on the Mutual Reduction of Forces and Armaments and Associated Measures in Central Europe, more commonly referred to as Mutual and Balanced Force Reductions (MBFR). SALT II is based on the Vladivostok agreement for initial limits (e.g., 2,400 total strategic nuclear delivery vehicles, SNDVs, and 1,320 SNDVs with multiple independently targetable reentry vehicles, MIRVs). The reestablishment of equal numerical limits below the Vladivostok levels, counting rules, verification aspects, future testing, and associated measures have evolved through extensive and difficult negotiations between U.S. and Soviet officials. Critical issues concerning "essential equivalence", strategic stability, quantitative limits with few qualitative controls, hedging, verification, and allied implications have resulted in widespread publication of details of the proposed treaty, an accompanying temporary protocol, and a follow-on statement of principles which would

lead toward further strategic arms negotiations. Resolution of some U.S. and Soviet differences is indicated in the open literature--for example, the overall SNDV quantitative level (2,160/2,250)[3] and the effective date to achieve that level (31 Dec 1980/mid 1982)[4], representing US/Soviet preference respectively, have apparently been resolved at 2,250 SNDV's in 1981.[5] Other numerical details can be viewed chronologically to gain deeper insights into the negotiating process.[6] The probable terms include a Treaty (to expire 31 Dec 1985), a Protocol (to expire on December 31, 1981), and a Statement of Principles with the following major provisions:

SALT II Treaty:

-- Initial limit of 2,4000 SNDV launchers, decreasing to 2,250 by 1982.

-- Limit of 1,320 MIRVed SNDV launchers (ballistic missile plus air-launched cruise missile carrying bombers).

-- Ceiling of 1,200 MIRVed ICBM plus SLBM launchers, with subceilings of 820 ICBM launchers and, for the Soviets only, 308 operational (and 18 tests excluded) launchers for modern large ICBMs (ss-18).

-- Cruise missiles with ranges in excess of 600 kilometers will be limited to deployment on heavy bombers (U.S. B-52/CMC and Soviet BEAR/BISON) having externally observable differences from similar bombers not carrying cruise missiles.

-- Provisions concerning possible future cruise missile carriers, ICBM throwweight and launchers, non-circumvention, verification, and accouting.

Protocol:

-- No deployment of mobile ICBM launchers and no testing of ICBMs from such (test) launchers.

-- No flight test or deployment of new ICBMs or SLBMs (one exception of each per side), with new being defined as more than 5% larger or smaller than the missile to be replaced. Modernized replacement missiles within the size limits are not constrained.

-- No flight testing or deployment of air launched baliistic missiles with ranges exceeding 600km.

-- No deployment of SLCM or GLCM with ranges exceeding 600 km, but development and testing are allowed.

-- No increase in the number of reentry vehicles per missile above the number previously tested on that missile type.

Statement of Principles:

-- Attempt further reductions and qualitative limits in strategic weapons systems.

-- Address U.S. and Soviet "gray area", peripheral attack, and forward-based systems.

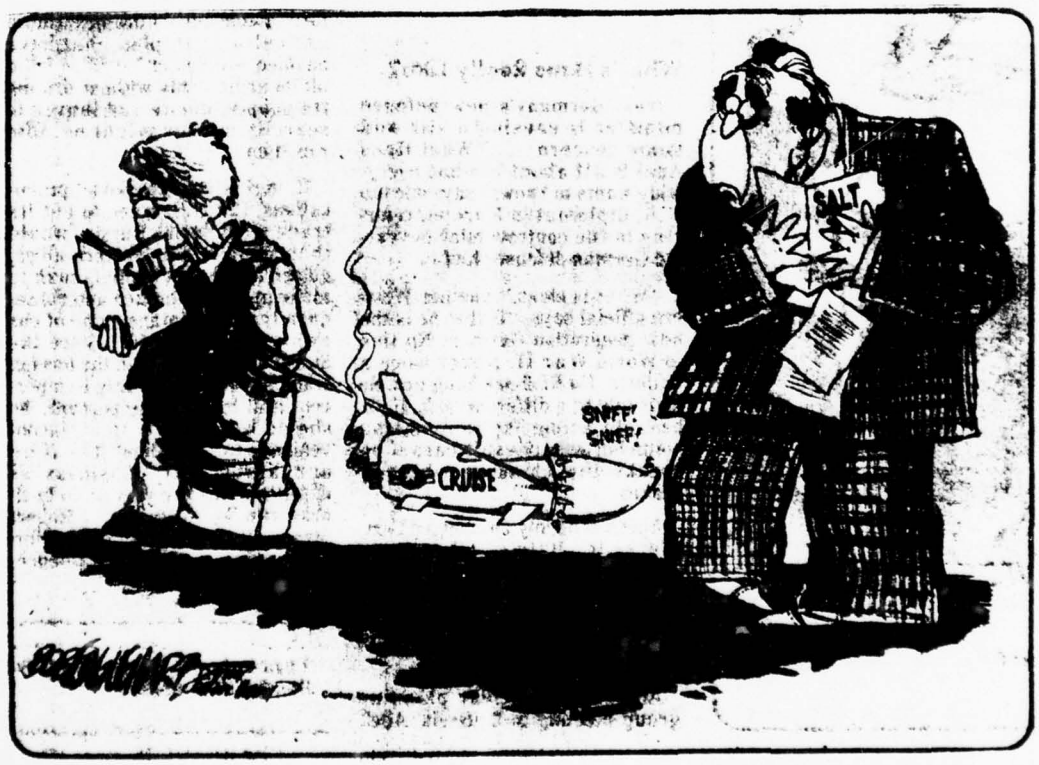
-- Maintain and enhance survivability of SALT II permitted systems to strengthen strategic stability.

The agreement to equal limits is significant, given the asymmetries in national policy, defense strategy, and other basic factors (e.g., alliances, geography). Whether SALT II achieves its basic purposes in the most effective or equitable terms, some degree of restraint has been introduced. The ensuing debates, together with shifted priorities toward allowed qualitative improvements, point toward the views of diverse organizations and individuals--opponents include hard line hawks(who would prefer higher ceilings and increased budgets) and avid arms controllers (who believe that the agreed ceilings are too high).

proponents similarly range from those supporting any reduction to those who believe that "adequately" high levels are preserved. The resultant debate, while accepting both the process and the equal limits as beneficial, involves narrow technical issues and broader policy concerns across normal "party lines."

Cruise Missile Implications in SALT II.

"There are those within the U.S. government, as well as in the broader academic defense community, who see the U.S. cruise missile as the nemesis of arms control."[8]



Specific cruise missile issues in SALT II included:

-- Are cruise missiles "strategic"? Since SALT II grew from the Vladivostok accords the U.S. initially argued that only air launched ballistic missiles should be considered; the Soviets held to the view that long-range ALCM's (and other cruise missiles in general) should be addressed. All cruise missiles have been included in some manner.

-- BACKFIRE. The U.S. reconsidered the above view in an attempt to include BACKFIRE in SALT II; the U.S. offered to allow 250-275 BACKFIRE bombers as counted against a U.S. force of 250 total long range SLCMs on 25 surface ships, each with 10 SLCMs. The Soviets viewed BACKFIRE as a non-strategic, theater oriented weapon system, but eventually agreed to draft a concession statement (outside the treaty and protocol) concerning production (no more than 30 per year), deployment, and refueling constraints. Backfire does not count against the SALT ceiling on SNDvs; nor was a set of 250 SLCMs permitted for the U.S..

-- ALCM Loading. After the U.S. had agreed to include ALCM, counting against the ceilings became critical; should one ALCM count as heavily as one ICBM? For comparability, it was agreed in principle to treat ALCM's as MIRV warheads--the launcher counts as one, regardless of the loading number of warheads. Initially, the U.S. offered to count heavy bombers loaded with 12-20 ALCMs as MIRVed launchers, while the Soviets proposed that ten or more ALCMs would be the loading to count. The U.S. shifted from 12-20 to 40-60, after an unsuccessful attempt at no upper limit to allow for future wide bodied cruise missile carriers. This was countered by a Soviet proposal to allow 20 per aircraft.[9]

Bargaining to a 25 (Soviet)versus 35 (US) ALCM loading also addressed the manner of counting, with each and every aircraft equally limited versus an "average" approach. The average of 28 ALCMs per aircraft would be counted as the total ALCM's divided by the total aircraft with functionally related, externally observable differences from non-cruise missile carriers of the same air-frame type.[10]

-- Range. The U.S. initially proposed to include only those cruise missiles with ranges in excess of 1500 nm. The Soviets sought to allow any number of short-range (less than 1000 miles) and ban longer-range cruise missiles. The Treaty restricts long-range (greater than 600 km), but no upper range limit[11]) cruise missiles to deployment on aircraft counted as heavy bombers and as MIRVs. The protocol allows development and testing, but not deployment, of long-range ground and sea launched variants; shorter range cruise missiles are excluded and therefore allowed. Now that the dividing line is set at 600km, the follow-on issue concerns how to measure that range--launcher to target distance, allowing zigzag (US) versus actual flight path (Soviet) distance.[12] It appears that the latter will apply, effectively shortening allowed range. Broader cruise missile issues concern the political impacts of banning technology transfer as a non-circumvention measure.[13] the equity of the 600km range limits, exclusion of quid pro quo or reciprocal systems, the potential for the "non-temporary" protocol, verification, and conventional versus nuclear arming.

Allied concerns that bilateral negotiations will preclude exploitation of cruise missile deployments in support of Europe include specific anxieties that neither hardware nor blueprints will be forthcoming under provisions of non-circumvention. Until specific technical wording is available for review, the NATO allies must be reassured with general supportive statements by the U.S. officials. For example, Rep. Bob Carr (D-Michigan) noted that the allies haven't objected to the range limits on GLCMs and SLCMs, that there are NATO options (e.g., strategic and short range ALCM), and that there is "little problem in providing NATO nations with cruise missiles or the associated technology."[14] He argued that the U.S. shouldn't be concerned about the risk to the Soviets that short range cruise missiles could be modified to extend their range. The House panel of which Rep. Carr was a member stressed, in a majority opinion, vague non-circumvention language in the treaty and serious Soviet objections to transfer.[15] The vague language, which increases the risk of future Soviet charges of U.S. violation should transfer occur, could "alleviate" allied fears if interpreted as to allow transfer.[16] For clarification, the U.S. could formally announce its intent to transfer prior to signing the treaty.

The limitation restraining GLCM and SLCM to 600 KM ranges bears examination. Aside from the range definition issue (launcher to target versus flight path), the asymmetries of target coverage and existing systems should be considered.

If deployed at sea and launched from as far as the 100-200 fathom line, U.S. SLCM with a less than 600km range could hold about 15% of the Soviet population at risk--similar Soviet systems could target all major European cities and 69% of the U.S. population.[17] This potential coverage fails to note that the U.S. has no such deployed system; the Soviets have several thousand in types such as those shown in Table B-1.

TABLE B-1

SOME SOVIET CRUISE MISSILES

DESIGNATION		RANGE
	Air Launched *	
AS-1	Kennel**	90-150 KM
AS-2	Kipper	100-210 KM
AS-3	Kangaroo	185-650 KM
AS-4	Kitchen	300-800 KM
AS-5	Kelt	160-320 KM
AS-6	Kingfish	220-700 KM
AS-7	Kerry	?
	Sea Launched *	
SS-N-2	Styx**	Short range
SS-N-3	Shaddock**	240-720 KM
SS-N-7		50- 60 KM
SS-N-9	Siren	110-275 KM
SS-N-12		600-750 KM

* For ranges beyond the radar horizon (300 KM for a Badger or Backfire at 35,000 feet and 70 KM for a ship), some over the horizon targeting and midcourse guidance are required.

** Also seen in possible ground launched variants.

Sources:

1. World Armaments and Disarmament, Stockholm International Peace Research Institute Yearbook, 1978, (Crane, Russak, & Company, Inc., New York, 1978) p. 446-448;

2. "The Military Balance 1978/79" as compiled by the International Institute for Strategic Studies, London, Air Force Magazine, December 1978, pp. 70, 120, 122-123.

3. Ronald T. Pretty (ed.) Jane's Weapons Systems 1978, (Ninth edition) (Franklin Watts, Inc., New York, 1977) pp. 57-58, 143-145.

4. James E. Dornan, Jr., "SALT and SLCMs: The Asymmetrical Equation", Sea Power, August 1977, pp. 11-14.

5. Alexander Malzeyer, "Soviet Air Launched Cruise Missiles--Irrelevant to SALT II?" International Defense Review, Vol II, No. 1/ 1978 pp. 41-45.

6. "Missile Characteristics" Aviation Week and Space Technology, 12 March 1979, p. 98.

The range estimates shown above were developed independent of the cruise missile protocol range limit, implying that Soviet cruise missiles are in the 50-600 KM class and therefore permitted. On the other hand, reports of recent Soviet tests of a long range (646-750 NM) ALCM[18] might cause Soviet cruise missiles and the previously excluded BACKFIRE bomber to be reconsidered. A possible Soviet counterargument could excuse the tests since U.S. cruise missile tests from A-6 aircraft have been excluded; test bed aircraft don't count. Including U.S. cruise missiles in SALT while relying on unilateral Soviet assurances concerning Backfire reflects, at best, an unusual negotiations procedure. Exclusion of certain Soviet peripheral attack systems (although cruise missiles have been included as noted above) is cited by many defense analysts as a particular criticism of SALT II. Cruise missiles, as the U.S. quid, could have been addressed in the context of new ICBM's,

the BACKFIRE, and SS-20, the Soviet quo.[19] Failure to address reciprocal Soviet limits for cruise missile constraints primarily affecting the U.S. has made the SALT II treaty and protocol "even more controversial."[20]

SALT proponents accurately note that, in addition to imposing equal limits on U.S. and Soviet cruise missiles in the treaty, the protocol restricting deployment of cruise missiles having range capabilities over 600 KM is temporary, in fact, expiring before the U.S. plans to deploy such systems. The Soviets have unilaterally declared that the protocol is not open to negotiation after 1982, a promise of permanence. Similar views stress the likelihood of continued constraint of U.S. cruise missile programs through SALT II Treaty words allowing ALCM only, inertia, or SALT III.

> The protocol is obviously much more contentious: first, the United States is moving in the direction of a ban on SLCMs and Ground-Launched Cruise Missiles (GLCMs); an often heard charge against the protocol is that it will not expire; certainly the Soviet position will be to press for a continuation of the SLCM and GLCM restrictions... [21]

> ...it is always difficult politically for the United States to end a deployment moratorium ...the protocol does set a precedent for U.S. acceptance of continuing limits on cruise missiles... [22]

> ...Once something is agreed at the highest level by both sides, they [the Soviet side] act on the presumption it will continue indefinitely, unless payments greater than the cost of giving up the provision are made to them elsewhere. [23]

If the Protocol will expire by 1982 as designed, several cruise missile issues become "unagreed" or undefined at that time. Notwithstanding the continued Treaty terms on ALCM, non-circumvention (through transfer), long-range capabilities, type of arming, and allowable quantities become GLCM and SLCM topics of renewed concern. Even should the United States believe that transfer of ALCM hardware or technology would violate the non-circumvention clause in the Treaty, GLCM and SLCM transfer could be interpreted as acceptable, since neither is addressed in the Treaty. Even though the Treaty limits only the long range ALCM (actually the carrier), long range GLCM or SLCM might not be deployable due to Treaty language restricting long range cruise missiles to deployment only on "heavy bombers."* A similar poorly defined gap in 1982 would concern arming--nuclear or conventional--covered now only in the Protocol. Lastly, it is inconceivable that long-range GLCM or SLCM would be banned from deployment one day prior to protocol expiration, then quantitatively unrestricted the day after expiration--pressures to continue some form of controls would seem to be highly likely on both the Soviet and U.S. sides. If the Protocol is extended, as the Soviet declaration suggests at this time, deployment of long range GLCM and SLCM would be banned until the Treaty expiration date in 1985.

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* Protocol language may allow long-range GLCM and SLCM by 1982.

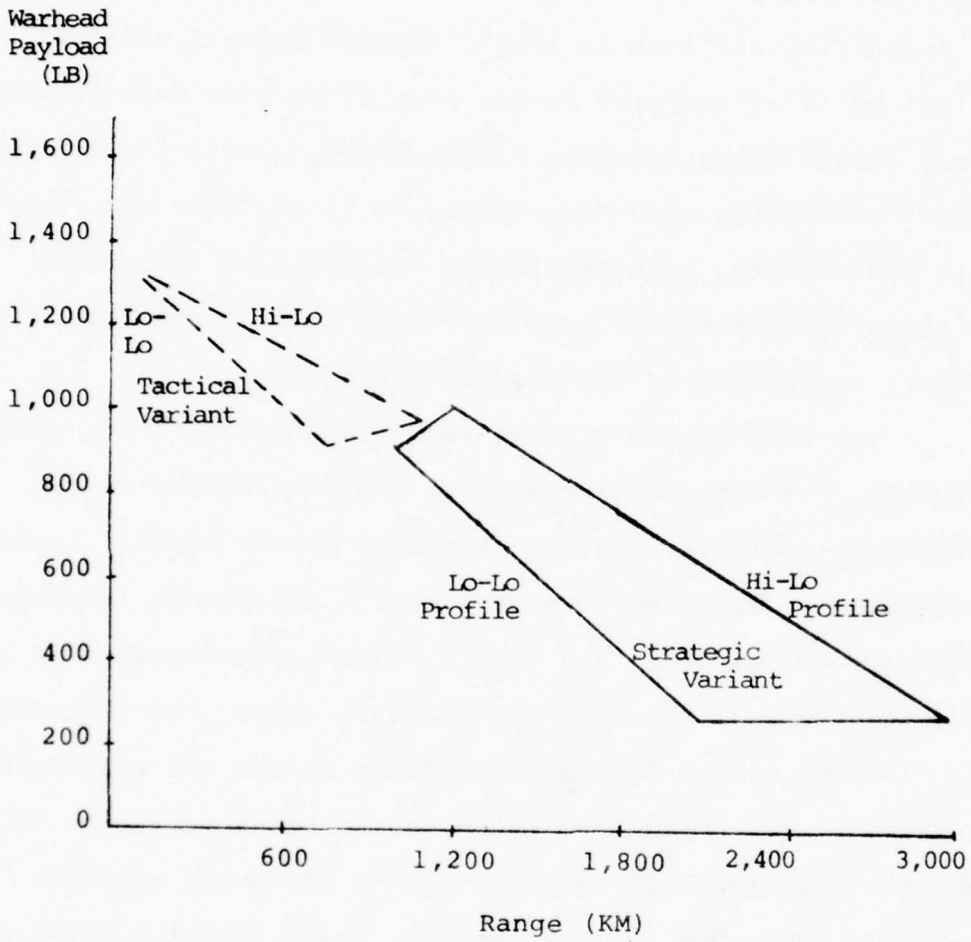
Perhaps the biggest hurdle in SALT is that of verification. Decreased U-2 and SR-71 coverage[24] and closure of seven monitoring stations in Iran[25] degrade overall national technical means of verfying Soviet compliance with SALT II terms. This may create incentives for readdressing on-site inspection, telemetry encryption, and "guarantees." In the case of cruise missile constraints, some particular verification issues include range determination, adaptable launch platforms (e.g., A-6 for ALCM), definition of arming, and transfer.

Inherent cruise missile range capability is not readily discernible from external appearance; a 600 kilometer cruise missile looks just like a 3,000 kilometer cruise missile. For a cruise missile designed to carry about 1,600 pounds (including guidance system, warhead, and fuel), range-payload tradeoffs are shown in Figure B-1. For the two variants noted, the tactical cruise missile, with a 210-pound guidance system and a 1000-lb. conventional warhead, could have range capabilities of 630 to 950 kilometers; the strategic version, with a 100-pound guidance system and a 270-pound nuclear warhead, could travel 2,000-3,000 kilometers.[26] Inability to verify how far the tactical variant can't go would be complicated by European basing.

ALCMs on heavy bombers, allowed within the treaty constraints previously noted, are adaptable for carriage on other

FIGURE B-1

RANGE - PAYLOAD



aircraft on short notice. It would be incredulous to require, in advance of such a treaty break out, that other aircraft with hard points or weapons pylons (e.g., F-111, A-6) should be counted as heavy bombers. (Since cruise missiles have been flight tested from A-6 aircraft, a test-bed exclusion has been acknowledged.) The United States could argue that current terms do not prohibit smaller strike aircraft from carrying a cruise missile of indeterminate (short) range, further complicating the issue. In addition, distinguishing strategic ALCM from tactical sea-launched or ground-launched variants may be impossible. Procurement of many reserve and test missiles would complicate this count.

Although SALT II deals with strategic nuclear launch vehicles, the protocol prohibition against deploying long-range "armed" cruise missiles implies a need for on-scene inspection to guarantee conventional high explosive arming or a broadening of terms to include conventional high explosive armed missiles in the protocol. Coupled with unverifiable range limits, U.S. testing and deployment of short-range, high explosive antiship or land attack cruise missiles might be objected to by the Soviets as attempts to subvert the limits for longer range nuclear armed missiles.

Transfer of technology or significant components probably lacks definition sufficiently precise to satisfy Soviet xenophobic objections, particularly if the United States should

desire to share with our historic "special partner", the United Kingdom. Previous agreements to share critical design information with the United Kingdom might be conceived by the United States to allow transfer of nuclear cruise missile technology, which might not be detected as "hard fact" by the Soviet in any event. Implementation of NATO Allied Programs of Cooperation (POC) for cruise missiles, with U.S. nuclear custodians and allied firing crews, could be construed as no transfer (U.S. custodians retain ownership) or as total transfer of missile technology and hardware. If implemented, administrative (ownership) constraints would be difficult to verify. If the weapon system, less warhead, were provided under previously existing POC procedures, subsequent equipment modification to increase range probably would be undetectable, complicating the issue.

Verification constitutes a central topic in most articles and books concerning SALT. In addition, many Senators cite the need to ensure adequate verification as a prerequisite to their vote for ratification of the treaty.[27] Similar, often more technical, concerns by defense analysts over the last few years have fueled the verification debate.[28]

Cruise Missile Implications in MBFR

The forward based systems (FBS) implications of theater based cruise missiles, together with their unverifiable non-strategic range, could present serious problems. The Soviets earlier demanded that FBS be addressed in SALT, with clear linkage

to Mutual and Balanced Force Reductions (MBFR). U.S. pressure to drop the U.S. and Allied FBS as a SALT issue was rationalized by U.S. offers to reduce certain theater nuclear forces under Option III of MBFR. The 11 participating nations (Belgium, Netherlands, Luxemburg, Canada, West Germany, United Kingdom, United States, Soviet Union, Czechoslovakia, East Germany, and Poland) are seeking to create a more stable military balance in Europe at lower force levels and costs, while maintaining "undiminished security."[29] In November 1973, the U.S. proposed asymmetrical reductions in two phases of 29,000 U.S. and 68,000 Soviet troops and totals of 70,000 NATO and 130,000 Warsaw Pact troops to arrive at a common ceiling. As a "sweetener", the U.S. offered the so-called Option III in December 1975 to withdraw 1,000 nuclear warheads, 54 F-4 aircraft, and 36 Pershing launchers if the Soviets would withdraw 1,700 tanks (troop cuts would be as above). More recent offers by negotiators (e.g., 1,500 vice 1,700 tanks, 24,000 US/35,000 Soviet troops, and acceptance of ceilings) are still at some distance from agreeable compromises. The Warsaw Pact offer to reduce 105,000 troops and NATO insistence on 250,000 each proposed to arrive at a 700,000 man ground force level, showing data disagreements.[30] The FBS issue,, dropped from SALT in 1971 and formally reopened in MBFR in 1975, focuses on Option III to reduce nuclear launcher levels. Subsequent addition of more strike aircraft into the United Kingdom and discussion of increasing Pershing missile range capabilities

has undoubtedly heightened Soviet concern. Most likely the proposed introduction of cruise missiles into the European theater would be subject to serious Soviet objections.

"The ground- and sea-launched cruise missiles and enhanced radiation warheads will no doubt prove to be issues subject to obdurate bargaining if dealt with at MFR [MBFR]."[31] Further, if an agreed-to MBFR Option III implies a missile launcher ceiling in the NATO Guidelines Area, introduction of SALT II-allowable cruise missile launchers could be interpreted as U.S. unilateral abrogation of both agreements.

A countervailing view holds that Soviet refusals to include SS-20 (or SS-4 and 5) ballistic missiles or Backfire bombers in either SALT or MBFR should be met with NATO counterbalancing systems, including theater based cruise missiles, extended range Pershing, and more forward based "long-legged" aircraft. SALT is "strategic" and MBRF is restricted to the NATO Guidelines Area; both omit theater support or gray area systems (e.g., British and French SLBM, IRBM, bombers; U.S. F-111 in United Kingdom; Backfire; SS-20; carrier-based A-6, A-7; long-range Soviet Naval Aviation).

Future Arms Negotiations

> "...the Soviets are likely to agree to negotiate on Euro-strategic forces in SALT III as the three-year protocol limiting deployment of long-range ground-based and sea-based cruise missiles near expiration."[32]

The potential for SALT III, MBFR follow-on, or new gray area/FBS negotiations hinges on the success or failure of SALT II and MBFR. With MBFR apparently snarled in data disparities and multilateral disagreements, SALT II ratification bears assessment. At this point, with serious debate over details of the test, SALT II could fail for two reasons--the Senate could refuse to ratify or the President could delay or withhold submission of the negotiated treaty for fear of Senate rejection.[33] Increased sales pressure by the Administration, heightened debate in the press, recent world and domestic developments, and well advertised Sentorial interest in broad and critical issues indicate a high degree of likelihood that SALT II will not be ratifiable. Rough counts of probable Senate votes suggest an unsuccessful outcome for SALT II. Perhaps the strongest confirmation of this assessment is the President's determination to secure a congressional majority vote of approval, if the Senate refuses to ratify, or to observe the terms of a SALT agreement on his own authority, if a majority vote is not acheivable.[34]

> If the SALT treaty is not ratified and the Soviet Union does exercise restraint, then we would be willing to match that restraint to the extent that it is verifiable. [35]

SALT II ratification or unilateral Executive action could lead to future, continued cruise missile constraints (as well as triggering a constitutional debate if ratification is

unsuccessful and the President acts as reported).[36] Bureaucratic inertia to not deploy GLCM or SLCM, extension of the "temporary" protocol as SALT II½, or addressal of cruise missiles in new negotiations might suggest revised plans to exploit the potential of cruise missiles with ranges less than 600 KM. On the other hand, viewing the significant military power potential cruise missiles offer in support of military strategy and national policy, it is not yet too late to press for longer range GLCM and SLCM program guarantees to provide both with deployment plans consistent with SALT II.

If SALT II is ratified, or the protocol terms are approved in some manner, the expiration of deployment limits should be guaranteed, with coordinated GLCM/SLCM program milestones established to provide enhanced theater capabilities to meet U.S. and NATO policy needs. Prior to considering constraints on cruise missiles in follow-on arms control negotiations, explicit approval of tolerable terms should be secured from NATO allies.

> To foreclose the development and deployment of this low cost "equalizer" either voluntarily or by formal treaty would be egregious folly. The task confronting the United States, therefore, is to make effective use of its technological assets, existing and potential, in the structuring of a military balance adequate to the needs of the United States and others whose security will be dependent on U.S. capabilities in the 1980s. For this purpose the cruise missile represents a weapons technology that should be regarded not as a "bargaining chip," but rather as a defense bargain available to the United States at a critically important time in its strategic-military relationship with the Soviet Union.[37]

APPENDIX C

CRUISE MISSILE SURVIVABILITY

Survivability

A prerequisite to the examination of cruise missiles, or of any other weapon system, must include some assessment of the likelihood of the weapons arriving at an appropriate target despite enemy attempts to preclude arrival. Survivability prior to launch, in flight, and in the vicinity of the target under attack should provide some high degree of confidence that a militarily effective warhead can be delivered. Prelaunch survivability is launch platform sensitive, since threats vary. Mobility, dispersion, concealment, hardening, and active defense are some factors which need to be judged in light of enemy acquisition, targeting, and engagement means. In flight survivability must weigh system reliability and characteristics. Terminal defenses present the last sequential threat to a penetrating weapons system.

Pre Launch Survivability

Pre launch survivability, at least in sufficient numbers to allow eventual effective employment, is a desirable characteristic in assessing the value of cruise missiles. Hardening, dispersal (including rearward or vertical displacement), concealment, defenses, and mobility contribute to survivability. For all theater nuclear forces, certain peacetime considerations tend to degrade survivability against pre-emptive attack. Safety, security, and economy have directly influenced the peacetime posture and location of

nuclear weapons ashore and on board deployed vessels. The absolute need to preclude accidental detonation, capture, or sabotage has inflicted numerous operational constraints and complex regulatory controls on military forces having custody of nuclear weapons. The resultant burden in providing more people and enhanced facilities has created strong offsetting economic pressures to consolidate or limit theater nuclear storage sites or weapons carrying vessels. Operationally, this can result in increasing the bolt-out-of-the-blue vulnerability by creating fewer (and more distinguishable) high value targets.

Similarly, conventional munitions storage overseas is receiving increased security awareness. Although security improvements are not as extensive as for nuclear ammunition storage sites, increased guard forces, security alarms, and lighting tend to increase the target visibility of conventional ammunition bunkers.

Peacetime concerns, pressing for consolidation of nuclear weapons storage for security reasons, also include desires to harden those sites ashore. Earth covered magazines of reinforced concrete with alarmed, thick steel doors provide some security from intrusion or attack in peacetime, as well as prividing protection from conventional high explosive attacks in initial phases of wartime. Concealment of peacetime storage sites is virtually impossible, with security requirements for lighting, fencing, and defensive structures producing

clear signatures identifying the sites. Hardening, with ineffective concealment, of nuclear and conventional sites might decrease the likelihood of successful conventional bombardment, while security forces can defend against possible peacetime terrorist or wartime patrol attacks. Neither are adequate to preclude a concerted Warsaw Pact, preemptive attack against well located fixed sites in an essentially peacetime posture. Survivability in ashore peacetime storage configuration cannot economically be adequately provided by dispersal or mobility due to safety and security concerns.

Pre launch survivability of sea-based nuclear weapons and forces can take advantage of these latter factors and, therefore unalerted, deployed naval weapons systems are less vulnerable to preemptive attack. In particular, submarines are recognized to have an excellent probability of evading detection and engagement, while surface ships can be more easily located. Both surface and subsurface forces are less vulnerable than fixed land storage sites in a peacetime posture. Active defenses can improve the survivability of storage sites and delivery units, afloat or ashore, although high confidence defense against preemption is difficult, if not impossible. Pre launch survivability of delivery forces in garrison ashore and perhaps aboard forward deployed surface vessles is low in a surprise attack scenario; defense against a bolt-out-of-the-blue attack could imply an unaffordable expense.

Once alerted, ground based theater forces can improve the pre launch survivability of launch systems and nuclear or conventional warheads by dispersing to field positions. The pre launch vulnerability of a ground launched cruise missile force should then "be comparable with existing field artillery missile systems."[1] Since the GLCM range allows for land basing well to the rear, system survivability is probably more similar to Pershing (400 nm range) than the more forward deployed Lance. Rapid dispersion in anticipation of conflict, camouflage in field positions, and frequent relocation should allow GLCM to be at least as survivable as Pershing. Considering that GLCM units would have fewer and smaller vehicles per location than Pershing forces, with many GLCM associated vehicles displaying visual characteristics common to less threatening units, GLCM pre launch survivability should exceed that of any current type delivery unit, certainly above 90%. Alerted surface and submarine SLCM forces would not display any marked improvement in pre launch survivability over peacetime posture. Once dispersed, concealed, and in a random relocation mobile configuration, GLCM forces might be slightly more survivable than surface based SLCM.

Surface ships with SLCM would be more survivable in a peacetime posture, since dispersal and mobility are allowed. Active defenses could assist the system survivability during hostilities, but surface ships are probably not quite as survivable as concealed GLCM, although more survivable than fixed site GLCM.

Submarines with SLCM are clearly more survivable, being less detectable, harder (under water), and mobile. Estimates of prelaunch survivability are highly scenario dependent, but certainly GLCM and SLCM forces are more survivable than current theater forces.

In Flight Vulnerability

Aerodynamic subsonic vehicles are clearly vulnerable in some degree to surface to air missiles and air defense interceptor aircraft. The detection, tracking, and engagement capabilities of airborne and land-based Soviet air defense systems against cruise missiles have been a subject of great controversy, with widely varying conclusions of air defense effectiveness and cruise missile vulnerability.

The surface to air missile (SAM) problem involves radar and missile electronics capabilities against the low altitude, terrain following profile, high subsonic speed, low signature cruise missile. Terrain masking and rejection of background clutter are common acquisition radar problems to be overcome in order to increase the potential time that the cruise missile can be seen and engaged.

Terrain masking problems can be partially offset by increasing the SAM acquisition radar antenna height. Normal earth curvature alone, without clutter, limits detection range to about 15 miles for a target at about 100 feet altitude; detection range can theoretically be doubled by installing the

antenna on a 100 foot tower. Proper radar siting to take advantage of hills can reduce this primarily geometric problem.[2] Conversely, the target cruise missile can reduce altitude to take advantage of masking (and hiding in clutter), but only to a certain extent.

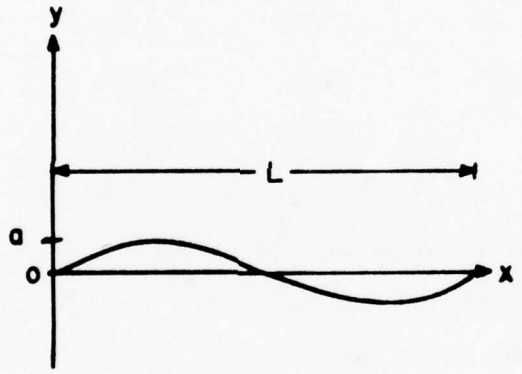
> A recent study by the Los Alamos Nuclear Weapons Laboratory raises a number of questions which have not hitherto received public attention about the utility of cruise missiles in Europe. Essentially, the study casts doubt on the ability of cruise missiles to penetrate to their assigned theater target. The study indicates that, if the altitude at which the missile flies is too low, the probability of crashing into the varied terrain of central Europe -- called 'ground clobber' -- rises beyond an acceptable level. At altitudes where ground clobber is not a problem, the task of radar detection and tracking is eased and the missile is much more likely to be shot down. [3]

Tradeoffs of clobber versus successful SAM engagement are not solely dependent on altitude. Radar cross section, speed, and terrain avoidance capability complicate the assessment. Tomahawk maneuverability is critical to terrain avoidance. At high subsonic speeds, the missile needs some altitude standoff for safety, particularly since the radar is not forward looking and must, therefore, rely on rates of altitude change to maneuver vertically. The capability to pre plan cruise missile missions allows mission planning to produce, in advance, a flight route to avoid the roughest terrain, which should allow an average cruise missile altitude of 50 meters over moderately hilly country.[4] One seemingly conservative unclassified estimate

of maneuverability notes, "...The Tomahawk is currently credited with a vertical acceleration capability of 1.5 g's which should permit it to follow a 6 to 7 percent grade at flight speeds of Mach 0.8."[5] This same report analyzes the kinematics of nap of the earth flight as shown in Figure C-1. This is basically a wave-topography analogy (basic sine wave equation) double differentiated and set to zero to deduce the maximum vertical missile acceleration required.

FIGURE C-1

NAP OF THE EARTH (KINEMATICS)



$$Y = a \sin (2\pi x/L)$$
$$Y = a \sin (2\pi CMt/L)$$

Where:

Y = Altitude (relative to average ground level, which is shown at Y = 0).
A = Maximum altitude above average ground level.
X = Ground distance
L = Terrain wave length
C = Speed of sound
M = Mach number
T = Time

From the above,

$$G\ (Max) = a\ (2\pi CM/L)^2$$

Table C-I, adapted from Figure VI-1 of the BDM report, shows resulting accelerations for 10 meter maximal hills (a = 10 in Figure C-1).

TABLE C-I

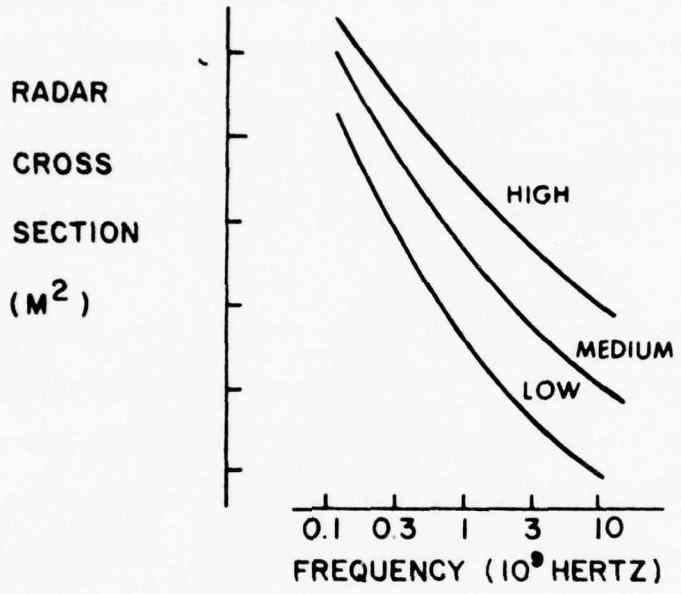
MAXIMUM VERTICAL ACCELERATION (g's)

	Mach			
L (Km)	0.6	0.7	0.8	Maximum Grade
0.5	3.36	4.57	5.91	12.6%
1.0	0.84	1.14	1.49	6.3%
1.5	0.37	0.51	0.66	4.2%

The principle SAM radar acquisition problem involves detecting small radar cross section cruise missiles at low altitude through clutter. Using moving target indicators, improving CW or pulse Doppler radar electronics to reduce noise, increasing the radar power-aperture product, improving range and azimuth resolution, increasing frequency/decreasing wave length, and generally cleaning up of backscatter and antenna reflector problems improve the ability of SAM radars to detect through clutter. For example, Figure C-2 illustrates the effect of increasing radar frequency to detect smaller targets or for improving the probability of detection of a fixed radar cross section air vehicle.

FIGURE C-2

PROBABILITY OF DETECTION CURVES



The curves represent a family of equal probability curves -- if an air target with a low radar cross section can be detected at some arbitrary (low) probability (the lowest curve) at 0.3 gigahertz, a comparable radar of higher frequency would have a higher probability of detection of the same air target (move right on the Figure to the medium curve). Or, if an air

defense radar system modernizes to a higher frequency radar, an offsetting reduction in radar cross section can be plotted. Many natural phenomenon (e.g., backscatter, wind blown tree limbs) are highly uncertain and complex in technical solution, thereby setting limits on computing ground clutter rejection, which is the key to acquiring low altitude targets. Again, decreasing altitude and radar cross section increase the cruise missile's ability to sneak up on, or hide from, air defense radars.

Decreasing radar cross section starts from minimizing the overall physical size, then streamlining functional protuberances (e.g., removing sharp metal edges from air inlet), using low or non-reflective exterior parts (e.g., fins), applying a radar frequency energy absorbing over-surface, and designing parabolic versus conical or flat surfaces where possible. Radar cross section is at a minimum when the aspect angle is about nose-on (perhaps plus or minus 45-60 degrees from nose-on) and unavoidably maximum in side view (perhaps plus or minus 20-30 degrees from side view). Unpublished Los Alamas data, probably from the previously noted study (note 2), suggests that the cruise missile radar cross section is in the 0.02 to 0.2 square meter range.[6] The 0.02 square meter radar cross section might be consistent with the forward (or rear) quadrant described above, constituting a significant reduction from aircraft or previous missile cross sections.

Similar reductions in infra-red signature and visual contrast reduce the probability of detection, or at least the range at which it may be acquired, decreasing the possible time of exposure to SAM engagement.

If detected and acquired, the cruise missile presents two other SAM problems; tracking radar multipath errors and SAM fuzing. Tracking any target requires precise location information; in the case of low altitude targets, radar signals that glance off the ground yield ambiguous range and vertical angular location data from directly reflected return signals. The resultant multipath errors tend to confuse the SAM system computer (and the SAM itself, if it includes an active tracker/homing system). Multiple targets or saturation tactics greatly compound the tracking and engagement problems.

SAM radar fuzing can similarly be confused by low altitude approach seeking to neutralize the cruise missile. The radar is designed to trigger at some returned signal strength threshold indicating that the target cruise missile is within lethal range of the SAM warhead (some few meters). For very low altitude targets, SAM fuzing signals that produce strong reflecting signals from terrain features enroute to the projected cruise missile intercept point result in premature detonation of the SAM warhead. Cruise missile proven design characteristics maximize its PTP.

> After launch, the missile would penetrate to the target at relatively low altitude and high speeds. Its route would be circuitous and easily programmed around known strong enemy air defenses. Tomahawk is being designed to have a small radar cross section, and attention is being given to its infrared signature.[7]

The ability to pre plan an attack to arrive from any direction, coupled with a low radar cross section, low altitude, nap of the earth flight, high subsonic speed, and defense avoidance (in time and space) contribute to the cruise missile's high PTP against current and projected SAM defenses. Evaluation of PTP must consider the dynamic interaction of the cruise missile attacking force and the SAM, anti aircraft artillery, and air defense aircraft system, as well as the terrain and environment associated with the scenario under examination. Assessments of cruise missile vulnerability which conclude low PTP often are based on defense optimistic/cruise missile pessimistic assumptions, in some cases compounded by an unrealistic scenario (e.g., a single cruise missile attempting to penetrate 2000 nm of alerted defenses). It should be noted that Tomahawk flies lower and is smaller than tactical aircraft, although it contains no exotic countermeasures and cannot evade suddenly discovered radars or SAM sites. For comparison, SAM effectiveness against aircraft has not been significantly high. During the Viet Nam War, about 380 SAM's of all sorts were fired per U.S. aircraft hit; in the 1973 Arab-Israeli war, 30 Arab SAM's and 10 Israeli SAM's were fired per aircraft hit.[8] Cruise

missiles should do significantly better, even considering possible multiple engagements in a heavier SAM defensive area. Postulated required improvements to the SA-10 include about 16 to 20 db better gains in radar sensitivity to detect a cruise missile at 35 Km, about 40 db improvement in clutter rejection, terminal homing to reduce multipath errors, and upgrading SAM fuzing.[9]

Reported tests of Soviet MIG-25 interceptor aircraft tests with look down, shoot down radar against drones at altitudes below 200 feet postulate an increasingly modern air defense threat.[10] It should be noted that the tests were against a drone, an unmanned aircraft, with a radar cross section comparable to a T-33 jet aircraft (about 20 times that of a cruise missile, which has a radar cross section of about 0.05 square meters).[11]

The most sweeping and most informed appraisal of in flight survivability concluded that the entire Soviet system of more than 10,000 early warning radars, more than 1,000 currently deployed SAM systems, and more than 1,000 interceptor aircraft is "totally useless" as a system to defend against a large volume (more than 1,000) cruise missile attack against the Soviet Union.[12] Dr. Perry went on to postulate that 100 AWACs type aircraft; several thousand interceptor aircraft with new, modern look down, shoot down radar and missiles; and 500 to 1,000 SA-10 sites, each with perhaps ten missiles, might be

needed to adequately defend (50% attrition of the cruise missile attack) a significant percentage of targets in the Soviet Union -- total cost $30 to 50 billion. He further noted that, "if we saw them moving in this direction, we would clearly want to respond to that with changes in our own program,"[13] later suggesting penetration aids, higher speeds (supersonic), and smaller size for cruise missiles. Dr. Perry concluded from Tomahawk survivability tests that:[14]

- Existing Soviet early warning radars could detect Tomahawk, but at "considerably less range" than aircraft and with "very poor accuracy",
- Existing ground control intercept and SAM acquisition radars would either fail to detect cruise missiles or detect them too late,
- IR-guided air-to-air missiles "were generally ineffective" due to imprecise interceptor vectoring and difficult pilot visual acquisition,
- "None of the radar-guided air-to-air missiles that the Soviets have will be effective against the cruise missiles" due to ground clutter obscuration,
- It would take ten years for the $30 to 50 billion Soviet upgrade of 100 AWACs, 1000 interceptor aircraft with look down, shoot down radar and modernized air to air missiles, and about 1000 SA-10 sites with ten missiles each,
- Soviet defense efforts could be detected and countered through revised U.S. programs (e.g., smaller, "jinking" maneuvers),

- IR-guided SAMs "were totally ineffective because of inadequate acquisition information", and,
- Radar guided SAMs "were totally ineffective or else had such a small lethality envelope as to be not useful".

Terminal Defenses and Survivability

Dr. Perry's statements cover, at least in part, concerns about the ability of the SA-10 to provide adequate terminal defenses against the cruise missile.[15] As noted earlier in this Appendix, dramatic SA-10 improvements would be required to create a cruise missile defense capability. Perhaps a more worrisome terminal, point defense could result from extensive deployment of more modern systems, including the SA-11.

SA-11 capabilities, shown in Table C-2, might be particularly applicable against cruise missiles.

TABLE C-2[16]

SA-11

Altitude	80 feet to 50,000 feet
Range	20 Km
Speed	3,300 feet per second
Maneuver	23 g

Deployment of three or four of the multirail SA-11 launch vehicles in the vicinity of SA-6 (Gainful) launchers implies

a high degree of overlapping SAM coverage and flexibility. Unknown details of missile fuzing and radius of lethality preclude firm conclusions of SA-11 effectiveness, although missile size suggests a very small warhead.

Numerous survivability test reports (by Martin-Marietta Orlando, Naval Ordnance Test Station, Caywood-Shiller terrain model equation, and BDM Air Defense Study) indicate point defense SAM probabilities of engagement from 0.017 to 0.78 for cruise missile altitudes above ground level of 30 to 75 meters (reaction time from line of sight to munitions arrival on target 12.6 seconds).[17] Terminal SAM kill probabilities, given engagement in the range shown, would probably be lower than 0.5, suggesting cruise missile terminal survivability against a single terminal defender to be in the 75 to 99 percent range. SAM effectiveness might be somewhat improved by firing two terminal defense SAM's in a shoot-look-shoot mode (missile tracking radar and at least initial guidance of SAMs from the ground preclude simultaneous SAM launches for most deployed SAM systems). But the high subsonic speed of a cruise missile would severely degrade the reaction time capability of the second (or later) SAM. Independent (launch and forget) operation and homing SAMs would allow multiple SAM launch.

Conclusion

Estimating cruise missile survivability is highly scenario dependent and technically complex, with great uncertainties existing. A wide variety of classified studies led

Dr. Perry, the Under Secretary of Defense for Research and Engineering to conclude that even dramatic Soviet expenditures over a long period could only attrite a large (1,000) cruise missile attack by roughly 50%. Detailed statistical and technical analysis of equipment capabilities, often safe-sided to provide a worst case estimate, tend to ignore, or down play, human confusion, exhaustion, motivation, and other socio-psychological facts present in combat situations. Although numerically modeling a SAM engagement versus a cruise missile appears scientifically exact over some range of uncertainty, human factors can severely degrade the manpower intensive early warning, command and control, and SAM system effectiveness in combat. The cruise missile, being unmanned, might be more "statistical" in performance.

Detailed assessments are nonetheless highly useful in confirming the beliefs and biases of decision makers; however, even the safe-sided studies seem to project relatively high survivability of the cruise missile against current and projected Soviet missile and aircraft defenses. Factoring in the subjective considerations, cruise missile survivability is considered to remain very high, perhaps 90%, in the near future.

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Theater sea launched and ground launched cruise missiles will be a part of U.S. and Allied military forces. As the means of military power enforcing national goals, forces should derive form, or be judged in terms of supporting national policy. Theater cruise missiles affordably satisfy these measures, thereby presenting a credible warfighting capability to deter agression and to defend by denying an enemy's achieving theater objectives, while being consistent with arms control and detente goals. Theater cruise missiles, in concert with other forces, will provide significant support of U.S. and Allied policy protecting vital interests.

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