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of
Limitations on Sea-Launched Cruise Missiles

by

Robin Keith Myers

March 1989

Thesis Advisor: Jan S. Breemer

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This paper examines the political and technical verification issues associated with proposals to place quantitative and/or qualitative limits on the deployment of nuclear armed sea-launched cruise missiles (SLCMs). Overviews of the arms control relationship between the United States and the Soviet Union, the development of the SLCM, and Soviet and American concepts of verification are presented. The views of the American arms control and defense communities regarding the SLCM is discussed in depth, accompanied by a detailed examination of the various methods which have been proposed to verify a SLCM limitation agreement. The conclusion is that there are no technological barriers, per se, to SLCM verification, but as the decision on an agreement's verifiability is a political one, the U.S. Navy should concentrate its arguments against SLCM limitations on the weapon's operational utility rather than argue that such an

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Political and Technical Verification Issues of Limitations on Sea-Launched Cruise Missiles

by

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requirements for the degree of

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ABSTRACT

This paper examines the political and technical verification issues associated with proposals to place quantitative and/or qualitative limits on the deployment of nuclear armed sea-launched cruise missiles (SLCMs). Overviews of the arms control relationship between the United States and the Soviet Union, the development of the SLCM, and Soviet and American concepts of verification are presented. The views of the American arms control and defense communities regarding the SLCM is discussed in depth, accompanied by a detailed examination of the various methods which have been proposed to verify a SLCM limitation agreement. The conclusion is that there are no <u>technological</u> barriers, <u>per se</u>, to SLCM verification, but as the decision on an agreement's verifiability is a political one, the U.S. Navy should concentrate its arguments against SLCM limitations on the weapon's operational utility rather than argue that such an agreement is unverifiable.

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I. INTRODUCTION

Senior officers of the United States Navy have argued that limitations on nuclear armed sea-launched cruise missiles (SLCMs) should not be included in the current Strategic Arms Talks (START) because such limitations are unverifiable. This position has rested on four arguments; (1) conventional weapons should not be included in a "strategic" arms control agreement, (2) the small size of the weapon precludes a confident estimate of the number of SLCMs in the Soviet inventory, while verification of such an agreement would be impossible since (3) one cannot distinguish between nuclear and conventionally armed SLCMs, and (4) it cannot be guaranteed that conventionally armed SLCMs would not be surreptitiously converted to nuclear armed ones.

This paper examines the last three of these arguments, all of which concern the issue of verification. The goal of this paper is to examine the political and technical verification issues associated with a possible agreed ban on SLCM deployment and to show that current verification technology is sufficient to provide "adequate verification" of a SLCM arms control agreement. This goal will be accomplished by first presenting an overview of the arms control relationship between the United States and the Soviet Union, particularly with regard to naval arms control measures. This presentation is followed by a discussion on the origins of the naval cruise missile. Next, the impact of SLCMs on American arms control thinking is discussed, and why SLCMs have become an arms control "problem." Both American and Soviet concepts of verification are discussed as is, finally, an in-depth treatment of the various methods of verification which have been proposed to underwrite a possible ban on SLCMs. This paper does not discuss, however, whether or not such an agreement is in the national interest, nor what would be the strategic, theater, or tactical impact of such an agreement were it consummated. It is the author's hope that the reader emerges from this discussion with a deeper appreciation of the political and technical issues regarding SLCM verification.

II. ARMS CONTROL BACKGROUND

What forces have motivated the United States and the Soviet Union to negotiate arms control agreements, especially nuclear arms control agreements? The answer from the American perspective can be gleaned from several of the works on arms control published, in the early 1960s, by members of the so-called "New Arms Control Consensus" (Lefever, 1962, p. ix).

A. MOTIVATIONS FOR ARMS CONTROL AGREEMENTS

1. American Motivations

These "consensus" scholars of arms control justified their support of U.S. - Soviet arms control measures on three grounds, the first one being the fear that thermonuclear weapons might destroy all life on earth. The potential destructiveness of nuclear warfare was repugnant to these scholars, who argued ". . . that the destructive power of nuclear weapons has made war politically obsolete and morally indefensible. No national interest or purpose, they held can justify the use of nuclear weapons." (Lefever, 1962, p. x) Arms control seemed the most promising method to save the planet from extinction.

A corollary to this view was a concern over the consequences of a nuclear war, namely the concern that "civilization, if not man himself, will be eradicated" (Brennan, 1961, p. 14). Since the authors assumed that there was "no defense" (Brennan, 1961, p. 14) against a nuclear exchange, there was "a growing interest in efforts to make war less destructive should we fail to prevent it, [which] is perhaps the central motive behind the present [1963] disarmament movement" (Lefever, 1962, p. x). Consequently, the risk of nuclear war had to be reduced.

Secondly, these scholars believed that the weapons buildup between the United States and the Soviet Union provided neither nation with enhanced security. "There is a growing realization among knowledgeable people that if the arms race is allowed to continue its accelerating pace, our country will have less security, not more, with each passing year" was how one scientific academic stated the argument[1] (Brennan, 1961, p. 14). Accordingly, technological breakthroughs on one side were expected always to be matched by the other, with the result that each side would be stockpiling as many weapons as

---

[1]Jerome P. Wiesner was at the time (1963) both Research Director of Electronics at the Massachusetts Institute of Technology and the Special Assistant to the President for Science and Technology. See Brennan, Notes on Contributors, p. 475.

possible, and each side would, in effect, be "arms-racing" against itself without hope of ever breaking the "stalemate." Thus, the arms race could not contribute to national security; instead it only made the risks of confrontation and nuclear weapon use more suicidal. (Brennan, 1961, p. 14)

The third American motivation for arms control evolved from the desire to "enhance the stability of the political and military relationship between the United States and the Soviet Union" (Lefever, 1962, p. xii). The goal was a reduction in the risk of confrontation between the two superpowers by means of so-called "confidence-building measures" (CBMs). These include various undertakings by both sides to make "transparent" to the other side the peaceful intent of certain military actions that might otherwise be misinterpreted or misunderstood, and possibly trigger an unwanted crisis.

A final important argument on behalf of arms control was economic, namely the notion that "an arms control measure may free resources for peaceful uses" (Blacker and Duffy, 1984, p. 75) yet, when reciprocated by the other side, would still leave both -- in theory, at least -- with proportionately equal levels of security. Arms control logic has held that money not spent on the "non-productive" development, procurement and life-cycle costs of a weapon can be readily redirected to the "productive" domestic economy.

The above arguments highlight the broad American motivations for arms control; some are shared by the Soviet Union, while others are peculiar to the Soviet perspective. Unfortunately, the closed nature of Soviet decision-making in the national security arena makes it very difficult to confidently identify what factors influenced the Soviet government to negotiate the first arms control agreements.

2. Soviet Motivations

One of the most important motivations pushing the Soviet Union to the negotiating table may have been ideological in origin. According to a Leninist world view, the "cause of the amassing of armaments is militarism," which is found only in capitalist countries (Vigor, 1986, p. 7, emphasis in original). Accordingly, socialist states are said to only accumulate arms to defend themselves against capitalist aggression. As capitalist militarism and aggression threaten the peace of the world, a goal of Soviet policy is to first slow down, and then stop, the arms race, eventually proceeding to actual disarmament measures. (Vigor, 1986, pp. 9-10) A recent Soviet work on disarmament argued that through joint efforts, the world's nation-states must formulate "a system to ensure a universal, lasting, and just peace. Thus, disarmament will be a major foreign policy effort of socialist states" (Potyarkin and Kortunov, 1986, p. 9).

Regardless whether Marxist-Leninist ideology provides the fountain-head for the Soviet Union's long range strategic goals, including arms control, one cannot judge Moscow's individual decisions on the strength of ideology alone. It is generally agreed in the West that another reason why the Soviets engaged in arms control negotiations was the same that motivated their American contemporaries: recognition of the destructive nature of thermonuclear war (Dallin and others, 1964, p. 20). Khrushchev once stated in both public and private "that the cost of victory in a showdown between nuclear super-powers would be such as to make the meaning of 'victory' ludicrous" (Dallin and others, 1964, p. 20). Additionally, this view of nuclear weapons helped, no doubt, to undermine the Leninist tenet on the "inevitability" of violent confrontation between capitalist and socialist camps. "War [could] no longer safely fulfill the socio-political function of enhancing the conditions" for socialist revolution. These considerations may have been at the heart of the strategy of "peaceful coexistence" when first announced at the Twentieth Party Conference in 1956. (Dallin and others, 1964, pp. 20-21)

The policy of peaceful coexistence was not to end the conflict between the communist and capitalist camps, but was aimed instead at redirecting the conflict into other (non-military) forms while helping to reduce the risk of military confrontation. This strategy (which is still considered valid today) helped set the stage for "partial measures," which "include both measures to regulate the limitation, reduction or elimination of individual systems and types of weapons as well as measures to contain and halt the arms race in specific geographic areas" (Potyarkin and Kortunov, 1986, p. 11). Although general and complete disarmament remains the declaratory goal of the Soviet Union, its leadership realized that this goal could not be achieved instantaneously, with the stroke of a pen. "Partial measures" provided a path towards the goal while also helping to reduce the risk of confrontation between the superpowers.

The economic argument for arms control has also been made in the Soviet Union, where the potential benefit of reduced military expenditures might be much greater than in the United States. Although precise data are impossible to obtain, estimates have placed Soviet defense spending in the early

1960s at a level between 11.3 and 15 percent of the Soviet Gross National Product (GNP). These figures do not far exceed the U.S. expenditure of 10.3 percent of GNP on the military in 1963. Soviet military expenditure, however,

> weighs more heavily on the Soviet than the American economy. Despite its smaller population, the United States annually produces approximately double the GNP of the USSR and can thus afford with less strain to spend a tenth on military affairs (Larson, 1969, pp. 84-85).

Thus, the economic incentive for the Soviet interest in arms control seems self-evident. The nature of the Soviet economy, however, centrally controlled and command oriented, prevents the population from applying much influence on central decision makers. The result is that economic benefits "are likely to be a reinforcing rather than a compelling" argument for arms control (Dallin and others, 1964, p. 24).[2]

Although the foregoing considerations may provide the general framework for why the Soviets entered in arms control negotiations, several Western commentators have also identified what they believe to have been the immediate

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[2]Since the currently ongoing efforts at economic perestroika, or restructuring, and glasnost, or openness, allow greater communication of economic dissatisfaction from the "man-in-the-street" to the key leadership, the economic rationales of arms control have received greater publicity. Arms control policy, however, as a key component of a national security and defense strategy, is probably still primarily guided by military-political rationales.

catalysts for the Soviet decision to go to the negotiating table. The first one may be, in fact, a "mirror image" of U.S. thinking, namely the belief that the Soviet leadership had come to accept the American concept of Mutual Assured Destruction. This concept holds that deterrence is best served by "maintaining at all times a clear and unmistakable ability to inflict an unacceptable degree of damage upon any aggressor, or combination of aggressors..." (Freedman, 1986, p. 758). During the mid-1960s, the then American Secretary of Defense, Robert S. McNamara effectively translated this criterion for deterrence into the ability to deliver 400 Equivalent Megatons (EMT) of nuclear explosives on the Soviet Union's cities and industries (Enthoven and Smith, 1971, pp. 207-208). It followed that any nuclear capability over this amount was an excess and thus could (or should) be eliminated through arms control measures.

Another argument that has been presented to explain the Soviet "embrace" of agreed arms controls has been progress, since the early 1960s, in solving the problem of "intrusive" verification. With the practical advent of so-called national technical means of verification,[3] i.e., mainly satellite

[3]The term "national technical means of verification" was first used in the SALT I agreement.

systems, the prospect was opened for ensuring arms control compliance without the need for intrusive, on-site inspections and monitorings. Being a closed society, the Soviet Union had consistently rejected agreements which depended upon such verification procedures. (Arms Control and Disarmament Agency, 1976, p. 17; Shearer, 1984, p. 33)

Although none of the factors discussed above can capture the whole of Soviet motivations for entering into arms control negotiations in the early 1960s, their sum probably covers the majority of factors that influenced the Soviet leadership's decision making in this regard.

B. OVERVIEW OF US/USSR ARMS CONTROL RELATIONSHIP

Arms control agreements between the United States and the Soviet Union since the early 1960s may be divided into four general categories: (1) confidence building measures (CBMs), (2) anti-proliferation measures, (3) technological ceilings, and (4) stockpile ceilings. Each is described below, along with specific examples.

1. Confidence Building Measures

Confidence building measures are designed to lower the risk of accidental confrontation between states by lessening the possibility of mutual misunderstanding or misinterpretation. CBMs can take many forms, but two most visible examples are the Washington-Moscow "hot-line," and the requirement for prior notification of large military exercises.

The installation, in 1964, of a direct communications link between the superpowers' national capitals, the so-called "hot-line," was one result of the Cuban Missile Crisis. During the Crisis, both nations were hampered by delays in communication between the leaderships; at least eight separate communications paths used have been identified (Allison, 1971, p. 217). The hot-line was "designed to allow the superpowers to clarify their intentions in case of accident, miscalculation, or misunderstanding and thus prevent an unintended war" (Blacker and Duffy, 1984, p. 118). Although the stated purpose of the hot-line is still to help prevent accidental war, its existence also allows for rapid and reliable communication between the two governments in situations not immediately threatening to either superpower. For example, President Nixon is believed to have used it during the September - October 1970 unrest in the Middle East (Blacker and Duffy, 1984, p. 118).

The prior notification CBM was a result of the Final Act of the Conference on Security and Cooperation in Europe, signed in Helsinki in 1975. Although the Final Act was not a "treaty" per se, the U.S. government has regarded it as such. The CBMs incorporated into the Final Act required that

> the parties exchange specific kinds of information. Prior notification is to be given of all major military maneuvers - those employing over 25,000 troops as well as smaller exercises whose character or location is judged by the holder to warrant notice (Blacker and Duffy, 1984, p. 296).

2. Anti-Proliferation Measures

The second category of arms control agreements between states may be called anti-proliferation measures. One of the stated motives of Soviet arms control policy is the establishment of "measures to contain and halt the arms race in specific geographic areas" (Potyarkin and Kortunov, 1986, p. 11). The Soviet concept of non-proliferation applies to weapons as well as to geographic regions, since, claim the Soviets, the reduction of the global stockpile of weapons is another step on the road towards the ultimate goal of complete disarmament. (Potyarkin and Kortunov, 1986, pp. 9-12 inter alia)

The Non-Proliferation Treaty (NPT) of 1967 was the first proposal in this category to become a ratified treaty. By its provisions, nuclear weapon states agree not to transfer nuclear materials to, or encourage the development of, nuclear weapons by the non-nuclear states. Additionally, the non-nuclear states who have signed the treaty agree not to attempt to acquire or manufacture nuclear weapons. (Blacker and Duffy, 1984, p. 393)

Nuclear weapons free zones (NWFZs) have been proposed many times for many areas of the globe. "The purpose of a nuclear free zone is to remove a particular area of the world from the nuclear arms race (1) by outlawing the introduction of nuclear weapons into the area and (2) by prohibiting the use of nuclear weapons against countries within the area" (Blacker and Duffy, 1984, p. 151). The only area specifically embodied in such a treaty is Latin America, so defined as to include the Caribbean Sea (Blacker and Duffy, 1984, p. 376). The Antarctic Treaty of 1959, while not specifically mentioning nuclear weapons, states that "Antarctica shall be used for peaceful purposes only" (Blacker and Duffy, 1984, p. 375). Additionally, the Outer Space Treaty of 1967 and the Seabed Arms Control Treaty of 1971 ban nuclear weapons in space and on the seabed respectively (Blacker and Duffy, 1984, pp. 121 and 124-125). Thus, non-proliferation agreements may be seen to comprise two types, those limiting the spread of nuclear weapons to individual nations and those attempting to prevent the presence or use of nuclear explosives in specific geographic regions.

3. Technological Ceilings

Mutual agreement to deliberately halt or slow down the acquisition of new weapons technologies may be considered the third category of arms control in the US/USSR relationship. This class of agreements attempts to limit the arms race and create a more stable international environment by limiting or preventing the development or testing of so-called "de-stabilizing" weapons technologies. The Limited Test Ban Treaty of 1963 is one example, and so is the SALT I ban on nation-wide U.S. and Soviet ballistic missile defense systems.

Discussions on the prohibition of testing of nuclear weapons had been a continuous facet on the international scene since 1957, when concerns over radioactive pollution from the atmospheric testing of weapons "reached a peak" (Blacker and Duffy, 1984, p. 126). A mutually declared, tripartite (including the U.S., the Soviet Union and the United Kingdom) moratorium on atmospheric testing of nuclear weapons was announced in late 1958, continuing until September 1961, when the Soviet Union resumed testing. The domestic U.S. political reaction to the Soviet testing resumption, the increasing evidence of biological effects caused by nuclear fallout, and the Cuban Missile Crisis prompted the United States government to increase its emphasis on achieving at least a partial, i.e., atmospheric, test ban with the Soviets (Blacker and Duffy, 1984, p. 129). Eventually, on 5 August 1963, a treaty, that permitted nuclear warheads to be tested only underground, was signed. A technological limitation on weapons development had been agreed to in the sense that,

> no one knew how much could be learned from underground testing, since relatively few underground tests had been conducted. Such testing was expected to lead to only some types of nuclear development. Therefore ending all other forms of nuclear testing was expected to slow the arms race (Blacker and Duffy, 1984, p. 113).

4. Stockpile Ceilings

The final category of arms control agreements between the United States and the Soviet Union may be called "stockpile ceiling agreements," as they attempt to limit the number and types of weapons and delivery platforms deployed by each party. The belief is that the fewer the number of nuclear weapons in the world, the more secure the world will be. Both the SALT agreements and the recent Intermediate Range Nuclear Forces (INF) agreement fall into this category.

The Interim Offensive Forces Agreement was signed in Moscow on 26 May 1972 and comprised one-half of what are commonly called the SALT I agreements.[4] One of the main provisions of this agreement was the prohibition of

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[4]The Anti-Ballistic Missile (ABM) Treaty is the other half.

construction of any new ICBM launchers. Thus, the number of launchers was fixed at 1,504 for the United States and 1,618 for the Soviet Union. (Blacker and Duffy, 1984, p. 232)

C. US/USSR NAVAL ARMS CONTROL RELATIONSHIP

Actual or potential naval arms controls can similarly be classified according to the four categories discussed above.

1. Naval Confidence Building Measures

The best example of a confidence building measure applied to naval affairs, and designed to reduce the chances of an accidental superpower confrontation at sea, is the "Agreement on the Prevention of Incidents on and over the High Seas" (Department of State, 1972, pp. 1168-1174). This pact prohibits the maneuvering of one's ships and aircraft in a dangerous or harassing manner while in the vicinity of the other's ships or aircraft at sea.

> The consensus on the operation of the agreement appears to be that it has succeeded in its purpose. Incidents at sea have been reduced considerably in numbers, but more importantly, they have become less sharp and potentially dangerous (Hill, 1989, p. 59).

With the signalling and communication provisions of the Agreement, it can be seen as a positive step towards reducing the possibility of conflict between the superpowers' ships at sea and thus, helping to reduce tensions between the two governments.

2. Naval Anti-Proliferation Measures

Anti-proliferation measures have also been proposed for naval platforms and for various oceanic areas. Nuclear weapon free zones (NWFZs) at sea are assumed, by their proponents, to add to international stability in the same fashion they presumably would on land, namely, the reduction in the risk of nuclear attack within the zone. (Hill, 1989, p. 161) Maritime NWFZs have been proposed at various times and for various regions, including the Mediterranean Sea, the Indian Ocean, and Nordic waters. Only for the South Pacific Ocean has a treaty been signed to make the region a NWFZ. This treaty, which has been ratified by Australia, New Zealand and eight other Pacific island nations, prohibits the manufacture, acquisition, possession, stationing, or testing of nuclear explosive devices in the region. The zone's boundaries are, approximately, the Equator, 115 degrees West longitude (almost to Easter Island), 60 degrees South latitude and the western edge of Australia's territorial waters in the Indian Ocean. (Survival, 1987, pp. 262-267)

3. Stockpile Ceilings at Sea

The United States and the Soviet Union have also agreed to ceilings on certain types of "naval" weapons, in this case "strategic" naval weapons. The limitations in question are incorporated in the Interim Agreement of the SALT I Treaty. This treaty limits the total number of "modern" nuclear-powered ballistic missile submarines (SSBNs) and "modern" submarine launched ballistic missile (SLBM) launchers each signatory may deploy: 710 launchers on 44 SSBNs for the United States and 950 launchers on 62 SSBNs for the Soviets (Blacker and Duffy, 1984, p. 421). Although never ratified, the SALT II Treaty also placed further restrictions on the number of warheads each SLBM can carry, (Blacker and Duffy, 1984, pp. 446-477) creating another stockpile ceiling for naval weapons.

At this point it needs to be noted that these two treaties, SALT I and SALT II, were the first agreements between the U.S. and the USSR limiting specific naval weapon systems. The SSBNs and SLBMs are "unconventional" naval systems of course. They are weapon systems that are part of the two nations' "strategic" arsenals, with the capability of striking the opponent's homeland over intercontinental ranges. Citing the SLBM agreements as precedents, recent naval arms control proposals by the Soviet Union have concentrated on what its spokesmen claim is the next most threatening sea-based weapon, also capable of striking deep within the Soviet homeland from a secure launch position, the nuclear armed sea-launched cruise missile (SLCM).

4. Recent Soviet Naval Arms Control Proposals

The current "Soviet Naval Arms Control Offensive" (Trost, 1988, p. 421) has tabled a variety of measures in addition to proposals for limiting systems of strategic range. In three speeches since July 1986, Soviet General Secretary Gorbachev has aired three broad proposals, each with the common theme of creating nuclear or military free zones at sea. These zones have been proposed for the Pacific and Indian Oceans, the Mediterranean Sea and northern European waters. (Simpson, 1988, p. 2) The United States has objected, arguing that any such agreement would restrict the rights of innocent passage of ships, and would unfairly benefit the Soviet Union. Russia, U.S. spokesmen have claimed, is a "continental" power, and could therefore "afford" restrictions on the movement of military forces at sea. The United States, by contrast, is a "maritime" nation whose very military and economic security rests on the unfettered use of the seas. (Trost, 1988, p. 423)

Of all the naval arms control proposals, the ones dealing with the SLCM apparently have the highest priority on the Soviet agenda. In fact, the Soviets have "linked" an agreement on SLCMs to any successful conclusion of the

Strategic Arms Talks (START) negotiation (Hildreth and others, 1988, p. CRS-24).

Following the Washington summit in December 1987, the United States and the Soviet Union pledged in a joint communique to work to "find a mutually acceptable solution to the question of limiting the deployment of long-range, nuclear-armed SLCMs" (New York Times, 12 December 1987, p. 10). This pledge was followed by a concrete proposal by the Soviet negotiators at the START talks in February 1988 to limit the total number of long range (i.e., minimum range of 600 km) SLCMs to 1,000, of which no more than 400 may be nuclear armed (Gordon, 1988, p. 3). Although a previous Soviet proposal attempted to limit SLCMs to certain classes of ships, this proposal has been withdrawn. The U.S. response to all SLCM related proposals has been negative, rejecting any limits on conventional SLCMs, and also rejecting "limitations on nuclear long range SLCMs as unverifiable" (Leggett and Lewis, 1988, p. 416).

Why have the Soviets been adamant about including SLCMs in the START agreements? One argument is that since the Soviets initially insisted that all U.S. cruise missiles with a range greater than 600 km be counted as individual strategic delivery vehicles,[5] and thus count as part of the START-proposed 6,000 delivery vehicle limit, their primary concern over SLCM is its capability to strike deep within the Soviet homeland (Huisken, 1980, p. 53). Additionally, the indistinguishability between the land and ship attack version of the U.S. SLCM, and between the conventional and nuclear warhead versions, greatly adds to the Soviet problem of tracking and identifying these weapons. When the weapon's "greyness" is combined with the U.S. Navy's proposal to obtain approximately 4,000 of these missiles, it becomes clear that Soviet counter-targeting and missile defenses will become very complicated. (Betts, 1982, p. 7; Johnson, 1982, p. 28)

Finally, there is the argument that "the Soviets are trying to obtain cheaply, through arms control, military objectives they cannot afford to attain through force building." Accordingly, the Soviets recognize the Western advantages in naval forces, and want to limit these advantages to the greatest extent possible "while maintaining their own advantage in ground forces." (Simpson, 1988, p. 5)

Having defined the basic parameters of the current U.S. - Soviet naval arms control "environment," it is

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[5]The Soviet Union defines long range SLCMs, at least for arms control purposes, to have a <u>minimum</u> range of 600 km (375 nm). See Blacker and Duffy, 1984, p. 452.

necessary to next provide a more detailed technical discussion of the SLCM "issue," especially the so-called "verification" aspect.

III. SEA-LAUNCHED CRUISE MISSILE BACKGROUND

The modern cruise missile has been defined as "an unmanned, expendable, armed, aerodynamic, air-breathing, autonomous vehicle" (Betts, 1981, p. 31). Sea-launched refers only to the types of platforms on which the missile is carried; i.e., naval combatants. This weapon traces its origins to the V-1 "flying bomb" of Nazi Germany.

A. AMERICAN SLCM DEVELOPMENT

Even before the end of World War II, American scientists recovered the remains of V-1 missiles from England and began to develop a similar missile (Werrell, 1985, p. 62). Throughout the late 1940s and early 1950s, the U.S. Navy also conducted research on the use of cruise missiles. The Navy's interest in this weapon was partially a result of its desire to have a system capable of delivering a nuclear weapon, a capability not resident in the Navy until the development of the rocket assisted, carrier launchable P2V bomber in the late 1940s (Werrell, 1985, p. 114). This research resulted in the Regulus I missile. The Regulus I, first declared operational in 1955, was 33 feet long and had a range of 600 miles. A follow-on missile was also developed, named the Regulus II.

Although a larger, faster and longer range missile than its predecessor, the Regulus II program was stricken in 1958 in favor of the development of a sea based ballistic missile, the Polaris. By 1964, even the Regulus I was withdrawn from active service.[6] (Werrell, 1985, p. 116)

The rapid rise and equally rapid fall of the American naval cruise missile in the 1950s may be traced to the continuing competition for systems capable of delivering nuclear weapons. In the realm of sea based long-range unmanned weapons, this competition pitted the cruise missile against the newly conceived submarine launched ballistic missile (SLBM). As development of the Polaris SLBM continued, this weapon appeared to have several advantages over the cruise missile. These advantages included reliability, reduced flight times to target and invulnerability to counter measures. The cruise missile's primary advantage was cost: it had a lower per unit price than the expensive new-technology SLBM. (Werrell, 1985, p. 108)

In the early 1970s, however, the concept of a long-range naval cruise missile was revitalized. The single greatest

[6]Admiral Elmo R. Zumwalt, who later as Chief of Naval Operations helped reintroduce cruise missiles into the Navy's weapon inventory, called the cancellation of the Regulus program "the single worst decision about weapons it [the Navy] made during my years of service." See Zumwalt, 1976, p. 81.

impetus to this rebirth came from, not the Navy, but the Office of the Secretary of Defense. In June 1972, Secretary of Defense Melvin Laird requested $1.3 billion for new strategic weapons, $20 million of which was earmarked for research and development into the "submarine-launched cruise missile" (Betts, 1981, p. 83). Secretary Laird's reasons for this request remain unclear, but several explanations have been put forward.

The most often repeated explanation for this impetus is that Secretary Laird wanted to use SLCM as a "bargaining chip" in arms control negotiations with the Soviet Union. The SALT I accords were signed the month prior to the Secretary's request. At the time "the United States had made an unsuccessful attempt to bring Soviet naval cruise missiles into the SALT I negotiations, and Laird felt that SALT II would produce the same result unless the United States launched a cruise missile program of its own" (Betts, 1981, p. 86).

Additionally, reports Betts, Secretary Laird believed that U.S. advances in weapons technologies, particularly in anti-ballistic missile defense, had helped secure Soviet signature of the SALT I ABM Treaty. A parallel process was hoped for naval cruise missiles; by developing its own SLCMs, the United

States would presumably be in a better negotiating position to limit them. (Betts, 1981, p. 86)

The monies requested by Secretary Laird were intended for the development of a long-range naval cruise missile. Given the limited successes of the 1950s with cruise missiles, one must ask what factors convinced the political leadership that a relatively small cruise missile, capable of accurately delivering a warhead to a distant target, had become technologically feasible. Two technological developments were of critical importance: small jet engines and improved guidance systems.

Guidance technology was an especially crucial factor in the development of the modern SLCM. Because of the missile's small size, the warhead, whether conventional or nuclear, also had to be small. Consequently, in order to destroy a target, the missile must detonate as close to that target as possible. The solution to the guidance problem was the use of TERCOM, an acronym for "terrain contour matching," in addition to a less accurate inertial navigation system (INS). An INS is used to guide the missile during its flight over water. Once ashore, TERCOM,

> corrects any inertial guidance error by taking periodic fixes on the terrain features over which the missile is passing. To do this, the system uses an on-board computer, in which maps of the relevant terrain are stored, and a radar altimeter. The computer correlates

> data received from altimeter readings with the altitudes shown on the maps in its memory. It then calculates the corrections needed to put the missile back on course and transmits this information to the missile's autopilot. (Gottemoeller, 1987, p. 7)

While the accuracy of the current generation of SLCMs has been a subject of much debate, open source estimates vary from a low of 250 feet to a high of 400 feet Circular Error Probable over a range of approximately 1500 miles (Betts, 1981, p. 88; Gottemoeller, 1987, p. 8).

The second development greatly facilitating the development of the modern naval cruise missile was the improvement made in small, fuel-efficient jet engines. By the late 1960s, an engine had been developed and successfully tested which was only 12 inches in diameter and 24 inches long (Werrell, 1985, p. 141). This engine was destined to be the predecessor of the current jet engines in use by U.S. SLCMs, the Williams International Corporation's 275 kg thrust turbofan (Blake, 1988, p. 459).

These small, fuel-efficient engines met the extended range requirements of these weapons. The range of the nuclear land attack Tomahawk, for example, is currently estimated at over 1500 nautical miles.[7]

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[7]The name Tomahawk was approved for the SLCM in 1975.

Weapons size was also an important factor in SLCM development. The original SLCM of Secretary Laird's proposal was to have been 345 inches long with a 32 inch diameter (Betts, 1981, p. 85). Chief of Naval Operations Zumwalt, however, argued for a missile which would be launchable from submarine torpedo tubes, ensuring that current submarine classes would have the same capability as newer boats, and thereby precluding the need to construct an entirely new class of submarine. Based on this requirement, the Tomahawk was limited to no more than 246 inches in length and a 21 inch diameter, exactly the size of a torpedo tube. (Werrell, 1985, p. 153)

The missions of the U.S. SLCMs, both nuclear and conventionally armed, have been the subject of much debate. "As always, . . . there are questions about the rationale for the SLCM" (Betts, 1981, p. 99). This is certainly not the Navy's perspective. In a recent article, the Deputy Chief of Naval Operations for Plans, Policy, and Operations presented his views on Tomahawk's current role in U.S. strategy. They are summarized below.

Primarily, Tomahawk is viewed as a "credible and significant component of nuclear deterrence" (Mustin, 1989, p. 186). Since nuclear armed Tomahawks are being deployed aboard many ships worldwide, complete Soviet counter target coverage is believed practically impossible. Thus, nuclear SLCMs can "threaten targets in the Soviet homeland with a high degree of assurance" (Mustin, 1989, p. 187). The result is an increase in Soviet decision making uncertainty, which is believed to contribute to deterrence.

Of late, Navy officials have promoted SLCMs as a key element in the NATO strategy of flexible response and a possible replacement for the "Euromissiles" that were removed under the terms of the INF Treaty. Without SLCMs, the argument goes, only vulnerable dual-capable aircraft remain to provide the link between battlefield nuclear weapons and American strategic forces, a situation which risks creating a "fire-break" in the flexible response strategy. (Mustin, 1989, p. 187)

Tactically, SLCMs are seen to "serve as a powerful warfighting naval equalizer, should deterrence fail" (Mustin, 1989, p. 188). "SLCMs . . . distribute naval striking power across a broad range of ships," whether the targets are afloat or ashore. By expanding the number of naval strike platforms, one can assure a synergistic effect between tactical air power and cruise missiles, an effect which has, in Admiral Mustin's view, "revolutionized the very nature of naval war." (Mustin, 1989, p. 188; emphasis in original)

Through the 1970s and 1980s, the Navy's SLCM survived attempts to restrict or rescind its development and deployment (Betts, 1981, pp. 89-90). In 1984 for example, both the Senate and the House of Representatives voted on amendments to the 1985 Department of Defense Authorization Bill to restrict the deployment of Tomahawk "unless the President certified that the Soviet Union had deployed similar weapons." Although the House amendment was adopted (Biddle, 20 June 1984, p. A 12), the Senate version was defeated, and nuclear armed SLCMs were deployed in the last week of June 1984 (Biddle, 28 June 1984, p. A 10).

B. SOVIET SLCM DEVELOPMENT

The development of modern U.S. SLCMs only tells one-half the story. The Soviet history of cruise missile development began in the immediate post-World War II era. The Soviet program, like its American counterpart, is heavily indebted to exploitation of captured German wartime technology (Breemer, 1985, p. 174).

The Soviet Navy has progressed through several evolutionary stages in its development of SLCMs. The first medium range (150 - 600 km) Soviet SLCM was the SS-N-3

Shaddock.[8] A contemporary of the U.S. Regulus missile, the SS-N-3 went into service in 1960. Armed with both nuclear and conventional warheads, the land attack version of this missile had an estimated range (to fuel exhaustion) of over 400 nm (740 km) (Polmar, 1986, p. 428; Couhat and Prezelin, 1988, p. 563).

A successor to the SS-N-3, the SS-N-12 Sandbox, became operational in 1973. Although similar in size and armament to the SS-N-3, but not commonly credited with a land-attack role, the SS-N-12 achieves supersonic speeds at the expense of range, being limited to approximately 300 nm (555 km) (Polmar, 1986, p. 429; Couhat and Prezelin, 1988, p. 564).

The SS-N-19 Shipwreck SLCM is the third evolutionary stage of Soviet medium range cruise missiles. First estimated to be operational in 1981, the SS-N-19 combines the best characteristics of its predecessors with the ability to be launched from either submerged submarines or from surface ships. (Polmar, 1986, p. 431; Couhat and Prezelin, 1988, p. 563)

The Soviet Union's most modern SLCMs are the SS-N-21 and the SS-NX-24, both of which are departures from the previous

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[8]This author will use NATO names and designations for Soviet missiles.

evolutionary SLCM development. The SS-N-21 is similar in size and appearance to Tomahawk, while the not yet operational SS-NX-24 is estimated to be much larger than the SS-N-21. Both of these SLCMs are estimated to be only nuclear capable (Department of Defense, 1988, p. 53).

The SS-N-21 and SS-NX-24 are departures from previous Soviet naval cruise missiles in two respects. First, these missiles have a much longer range than the SS-N-3 and its derivatives. In fact, their ranges approach that of the old SS-N-6 SLBM. Secondly, instead of employing an inertial guidance system solely, or an INS with mid-course guidance, the SS-N-21, and possibly the SS-NX-24 as well, are estimated to employ a TERCOM guidance system similar to the Tomahawk's. (Blake, 1988, p. 16)

These two factors of long range and accurate guidance support the American estimate that Soviet SLCMs will be used primarily in a theater, land attack role (Department of Defense, 1988, p. 53). The possibility of the Soviets targeting the U.S. mainland cannot be discounted, particularly the threat these missiles may pose against "soft" targets, such as Strategic Air Command bomber bases. The geographical launch envelopes to which Soviet submarines must transit to target the U.S. mainland, however, puts these submarines at risk from U.S. naval anti-submarine warfare.

This chapter has shown how the American long range SLCM, initially developed to serve as an arms control bargaining chip, has been given a variety of missions, from a "significant component of nuclear deterrence" to tactical anti-ship firepower, with either a nuclear or conventional warhead. Although Soviet missiles, assessed to be only nuclear capable, cannot yet demonstrate this wide range of missions, such a development cannot be discounted. To some, this multiplication of missions, while keeping the airframes indistinguishable, has resulted in an "unstable" weapons system whose numbers, characteristics, and deployment and employment patterns need to be constrained through agreed arms controls. The next chapter examines SLCM as an "arms control problem."

IV. SLCMS AND ARMS CONTROL

The very characteristics discussed above make SLCMs an "arms control problem:" they are nuclear armed, highly accurate, physically small and capable of flying great distances to their targets. It is widely held that these characteristics make it extremely difficult, if not impossible, to create a verifiable limit on the overall number of SLCMs, especially on the nuclear armed version. But verification concerns are only part of the "problem" between SLCMs and the arms control world. Because of their "greyness" (being neither completely strategic nor exclusively tactical), SLCMs pose important issues for American national security and military strategy.

A. NATIONAL SECURITY CONCERNS

The controversy that surrounds SLCM concerns the view that the weapon is inherently destabalizing to the Soviet-American strategic balance. This view stems from the fear by some that the Soviets could use their SLCMs in a "leading edge" attack against the command, control and communication nodes of the United States, as well as the national leadership, possibly as the first wave of a larger nuclear strike. By deploying both conventional and nuclear SLCM variants, the Soviets,

> would present the United States with an ambiguous attack threat. If the missiles were detected in flight, the possibility that they constituted a conventional attack would tend to suppress a U.S. urge to launch a nuclear response on tactical warning. (Gottemoeller, 1989, p. 177)

Additionally, it is said that the limited capabilities of the existing North American air defense system could not ensure detection of the incoming cruise missiles, thereby threatening a surprise decapitating attack against the U.S. National Command Authority (NCA). In this scenario, SLCMs could revitalize the role once played by YANKEE SSBNs deployed to the East and West coasts of the United States: a force capable of delivering a nuclear warhead against "soft" targets with little or no warning. Without advance warning of an impending nuclear attack, the U.S. ability to retaliate would be jeopardized, thereby creating an "unstable" situation that might provide the incentive for a Soviet first strike. Since an attack of this nature could be executed with just "<u>tens</u> of missiles," proponents of this view have recommended banning all nuclear armed SLCMs. (Postol, 1989, pp. 193-198, 201-202; emphasis in original)

The counter argument to this view argues that SLCMs <u>add</u> to, not detract from, stable deterrence by providing the

United States with a "flexible, mobile system, dispersed throughout the world's oceans" which "defeat Soviet targeting in advance" (Mustin, 1989, p. 186):

> Naval forces in general, and SLCMs in particular, offer options for extending a war, either geographically or temporally, thus denying Soviet victory even if they should achieve some initial success on the Central Front. This capability to offset Warsaw Pact superiority on the European continent is the most important reason for rejecting limitations on these [nuclear] systems (Mustin, 1989, p. 187).

Another controversy concerns the 50 percent reduction in strategic forces in the wake of a START treaty. Both the United States and the Soviet Union have already agreed in principle to a strategic force ceiling of 6,000 warheads on 1,600 strategic nuclear delivery vehicles (Hildreth and others, 1988, p. CRS-2), a position reiterated at the Washington summit in December 1987 (New York Times, 12 December 1987, p. 10). If deployment of nuclear armed SLCMs remains unregulated, there is concern that a significant circumvention of these limits could result (Harvey and Ride, 1988, p. 1). For example, the U.S. Navy has requested to procure 758 nuclear armed SLCMs (Gordon, 1988, p. 3) which, if fully deployed, would result in a 47.4 percent increase over the START limit on delivery vehicles, and a 12.6 percent increase in the number of warheads. Critics maintain that if the development and deployment of naval cruise missiles continues unchecked, including the eventual deployment of longer range missiles with supersonic speed, the START "limits" will lose more and more of their significance as a deep cut in the strategic inventories of the superpowers.

Conversely, Admiral Mustin is one of those who have argued that the numerical limitations of a START treaty could not be applied to SLCMs because "there is no practical means of differentiating between nuclear and conventional" variants (Mustin, 1989, p. 189). Since one cannot distinguish the nuclear and conventional variants, one cannot count the number of nuclear missiles available. Consequently, Admiral Mustin has argued that there should be nothing more than declaratory limits on nuclear SLCMs (Mustin, 1989, pp. 189-190).

The possible imposition of numerical limits on SLCM types and quantities has also raised several national security issues. The first concerns the possibly adverse impact of a limited SLCM inventory on the Navy's ability to execute its missions in the world external to Europe. A 600 (conventional) weapon ceiling (as has been proposed by the Soviet Union), of which only a fraction would be at sea at any one time, would severely limit the possible number of conventional SLCMs in a given area at a given time, thus reducing their potential impact on a regional conflict.

Alternatively, the Soviet-proposed floor of 600 km on the range of "long range" SLCMs has been called "artificial" (Yost, 1988, p. 5) and probably prejudicial to U.S. interests. The Soviets have at least three SLCMs

> with ranges far greater than the Harpoon (the SS-N-3, the SS-N-12, and SS-N-19), but have evidently not confirmed that any of them have ranges exceeding 600 km. The majority of current Soviet SLCMs (over 2,700 weapons) would therefore not be affected by the Soviet proposed treaty regime (Yost, 1988, p. 5).

Thus, a limiting agreement on SLCMs with greater than 600 km range would have no impact at all on the Soviet Navy's existing inventory of short- and medium-range SLCMs; it would only limit the new SS-N-21 and SS-NX-24.

The final national security consideration on a numerically limited SLCM inventory concerns the U.S. Navy's policy of neither confirming nor denying (NCND) the presence (or absence) of nuclear weapons aboard its ships, submarines or aircraft. The on-site inspection of U.S. ships or submarines as part of a SLCM verification regime would, of necessity, involve the confirmation by Soviet inspectors of the presence or absence of nuclear armed SLCMs, thus compromising the NCND policy. Although it has been suggested that the United States could trust the Soviet Union to uphold the NCND policy by the inclusion of a confidentiality provision in the treaty (Harvey and Ride, 1988, p. 7), this author believes that this is a dubious proposition. The NCND policy is applicable to more situations than U.S. - Soviet relations. Three areas of concern which immediately come to mind are terrorist threats to Navy ships, restriction of port calls abroad, and the freedom to navigate in waters which have been declared nuclear weapon free zones. The NCND policy preserves naval flexibility, minimizes placing friendly governments in embarrassing situations, and lessens the threat to U.S. naval personnel and assets. These advantages cannot be given away lightly.

B. VERIFICATION ISSUES

The first verification issue concerns the establishment of agreed data bases. If an agreement is signed limiting SLCMs, it will be necessary for both sides to determine how many missile airframes the other has manufactured. It is to be hoped that adequate procedures for this determination would be included in the agreement. Regardless, an inventory count would have to be obtained, since from this baseline current SLCM inventories will change to approach the agreed limits. Because of its importance to all subsequent verification, this accounting must be as accurate as possible.

Next, there is the problem of covert production and storage. In any inventory, the number of items is constantly diminished due to a variety of causes. In a SLCM inventory, these causes may include use of a missile for an exercise, operational life expectancy, or accidental damage to an airframe. To maintain the stockpile at its limit, missile production facilities must be maintained and new airframes constructed. The verification problem is to ensure that no excess missiles are produced and then covertly stored, so that neither side can accumulate, first a "creep-out," and next a "break-out" SLCM capability. The missiles' small size and the relative ease of manufacture of components greatly complicates the confident verification of a numerical limit on SLCMs.

The next verification issue has been touched on above: the indistinguishability between nuclear and conventional SLCM variants. It is widely thought impossible to identify, without access to the missile, its warhead package. Some verification techniques have been proposed to solve this problem, and will be discussed below (i.e., nuclear detection methods). They may provide an increased degree of confidence in identifying the missiles' warhead; without a highly intrusive inspection regime, however, it is impossible to confidently verify the number and type of SLCM available to the other party.

Another verification concern associated with the missiles indistinguishability is the possibility that a conventionally armed missile might surreptitiously be converted to a nuclear armed one. It has been reported that laboratory studies as early as 1972 proved the feasibility of matching the U.S. Navy's Mk-48 torpedo with a dual use, convertible conventional and nuclear warhead (Polmar and Kerr, 1986, p. 67). As a SLCM is the same size as a Mk-48 torpedo, it is reasonable that there are no technological barriers to the development of a convertible SLCM.

It can be seen that the arms control impact of SLCM is a complicated one. The impact of nuclear armed SLCMs on strategic stability and on START-agreed limitations is still being hotly debated. If a SLCM agreement is reached, there are concerns about the probable impact on the Navy's ability to execute its missions *vis à vis* not only the Soviet Union and the Warsaw Pact, but in a "violent world" elsewhere as well. The impact of such an agreement on the Navy's NCND policy can also be grave. The verifiability of an agreement limiting both conventional and nuclear armed SLCMs is a major concern: can agreed data bases be established? Can covert production and storage of SLCMs be prevented? Can one adequately verify a sub-ceiling on nuclear armed SLCMs given their external similarity to their conventionally arms cousins? It is these questions towards which this paper now turns. But, before discussing possible methods of verification, it is important to first understand the different Soviet and American perspectives on the concept and its practice.

V. CONCEPTS OF VERIFICATION

Why do nations need to verify arms control agreements? Why is verification such an important issue? These questions are at the core of the arguments surrounding verification. In the United States, there are at least three "schools of thought" on verification: substantive, legalistic, and metaphysical (Buchan, 1983, p. 16). This variety of opinion may also exist within the Soviet Union, however, there is only one official Soviet view on verification. This chapter will discuss not only the Soviet and American concepts of verification, but also why verification is so important and what its limitations are.

A. IMPORTANCE AND LIMITATIONS OF VERIFICATION

Verification of arms control agreements is important to governments for one overriding reason: these agreements limit what most nations believe to be their ultimate guarantor of security, i.e., their armed forces. Naturally, governments are loathe to reduce their military capabilities with respect to a potential adversary, but most are willing to negotiate away certain specific hardware items (and thus their capabilities) in return for increased security. This enhanced security is the greatest expected benefit of arms control agreements, but it is critically dependent on mutual confidence that the other side abides by the agreement in fact.

Unfortunately, there are no guarantees of the honesty of another government. A country must ensure that its national security is not threatened by violations of arms control treaties. If a violation is detected, one's confidence in the other's compliance is reduced and national security may be endangered. This concept is echoed by the U.S. Arms Control and Disarmament Agency which argues "verification of arms limitation agreements is necessary because the information required to ascertain compliance will probably not normally be available - and because a nation cannot afford to rely for its own security on trust alone" (Arms Control and Disarmament Agency, 1976, p. 3).

Verification, however, is not a "cure-all." It cannot do everything. Treaty compliance is a sovereign act of nations; it cannot be forced upon a nation despite the strictest possible verification regime; at best, the verification process can hope to detect and evaluate the magnitude of violations. Additionally, verification is partially a reactive activity; it can only respond to the activities of another party. As such, the verification process is always one step behind, continually following the actions of the perpetrator.

B. AMERICAN VIEWS OF VERIFICATION

The official U.S. position on the purposes of verification is given above, essentially, ". . . to ascertain compliance" with an arms control treaty. This statement allows for both broad and narrow interpretations of the requirements of verification, which chiefly depend, in turn, on the definition of compliance. As mentioned above, three schools of thought are prevalent in the United States.

The "substantive" school's greatest concern is not with the arms control agreement or with verification per se, but with the overall strategic balance. This school believes that "an arms control treaty can be adequately verified if neither side could alter the strategic balance by undetected cheating" (Buchan, 1983, p. 16). Proponents of this belief grant that small violations of a treaty are virtually inevitable. But, they insist, such violations are unimportant, that because of their "minuteness," they cannot by themselves be strategically significant. One prominent scientist and commentator on verification issues summed up this view as follows:

> Past experience with arms control agreements has taught us that it is not necessary to see everything, that

> "adequate verification" requires only that we be able to detect in a timely fashion any violation that could threaten the national security of either country (Tsipis, April 1988, p. 15).

The practical consequence of this view is that treaty verification regimes need not be very detailed or intrusive. Since only the violations by the enemy which affect the strategic balance are important, one need not be concerned whether weapons inventories precisely match the agreed limits. The key assumption of this school of thought is that <u>strategically significant</u> violations can be detected remotely, and that large violations that "matter" will be detectable by the verification method agreed to in the treaty.

The "legalistic" school is less willing to accept arms control treaty violations than are their substantive counterparts. Proponents insist that arms control treaties are just that: treaties made under the provisions of international law which bind the signatories to certain allowed and prohibited acts. This school regards a treaty "... as a legal contract and consider[s] violations to be serious issues <u>per se</u> regardless of their relative strategic significance" (Buchan, 1983, p. 16). Any violation is important not for its immediate military consequences, but for the conduct and expectations that it will set for future agreements (Krass, 1985, p. 143). A related consideration is that a small violation by the Soviet Union may be a test of the overall U.S. resolve regarding arms control treaties. It has been argued that "we should not tolerate non-adherence in small things lest we lose our credibility in insisting on adherence in large" (Slocombe, 1983, p. 81, cited by Krass, 1985, p. 143). Consequently, this school sees verification as a very important issue on its own merits, and insists on a very strict verification regime. Verification, proponents maintain, must be able to account for <u>all</u> the limited weapons at all times as this is the only way to ensure the fulfillment of the legal contract. As a corollary, this school inveighs against any verification regime which does not meet its strict requirements, calling them simply "confidence building measures," rather than verification measures.

The third school of thought in the American verification spectrum has been called the "metaphysical" school, which

> is the most difficult of all [the schools] to satisfy in terms of verification. Its concerns go well beyond the letter of any strategic arms agreement, insisting in effect that the Soviets conform to some unspoken behavior code and interpreting Soviet actions as measures of intent and character (Buchan, 1983, p. 16).

The strict verification regime of the legalistic school is not enough. Not only must the treaty be adhered to precisely and <u>in toto</u>, but also the Soviets must live up to the "spirit" of the agreement, particularly the American interpretation of that spirit. "The essential demand of the metaphysical school is not that the Soviet Union demonstrate compliance with arms control treaties, but that it prove the absence of non-compliance" (Krass, 1985, p. 144; emphasis in original). Thus, to the metaphysical school, the Soviet Union is presumed guilty of treaty violations until it proves itself innocent.

C. SOVIET VIEWS OF VERIFICATION

It is important first of all to understand Soviet definitions of terms such as "verification" and "monitoring." Unfortunately, precise and concise Soviet definitions of these two terms are not readily available. Generally, however, "in Soviet literature, the word kontrol' is used most often in discussing the verification process, especially to describe the overall process" (Spurlock, 1985, pp. 2.2 - 2.3). The kontrol' process is believed to have four distinct components; namely, (1) collection of data, (2) processing of information, (3) judging conformity to agreements, and (4) proposals of measures, if necessary, to change the situation. This process is akin to the United States' official definition of verification which states, in part, that "... in the vocabulary of arms control, verification refers to the process of assessing compliance with the provisions contained in arms control treaties and agreements" (Arms Control and Disarmament

Agency, 1976, p. 2). While both the Soviet kontrol′ process and the American verification process involve making judgments regarding a signatory′s compliance with an agreement, the Soviet variant also provides for procedures by which appropriate responses to perceived violations can be generated.

Another word of importance in the Soviet arms control vocabulary is proverka. Proverka is believed to be a component of the kontrol′ process, and can best be described as an "act of monitoring," or specific method of data collection designed "to augment the process of monitoring." One example of proverka would be an on-site inspection. (Spurlock, 1985, pp. 2.5 - 2.6; emphasis in original) Thus, proverka corresponds closely to the American concept of monitoring, a concept which covers all methods of data collection.

Unlike the actual definitions, the purpose of the Soviet verification process is clearly stated in, for example, Verification of Arms Limitation and Disarmament by Roland Timerbayev. Timerbayev, who has been the Soviet deputy ambassador to the United Nations and deputy director of the Soviet Foreign Ministry′s Department of International Organizations, is a recognized Soviet expert on disarmament and foreign policy (Timerbayev, 1987, p. 8 fn). The "only purpose of verification," Timerbayev states, "is to promote the fulfillment of disarmament agreements" (Timerbayev, 1984, p. 16). While this bald statement may be the only Soviet purpose of verification, Timerbayev nevertheless makes clear several additional points associated with the verification process. First, any verification provision must be linked "extremely closely to the process of limiting and eliminating weapons" as a "means of furthering the implementation of measures to restrain the arms race and achieve disarmament." Any other purpose of verification provisions, such as intelligence collection, is accordingly an improper use of that provision. (Timerbayev, 1984, pp. 12-17)

To ensure that the verification process does not go "beyond its purpose of contributing to the fulfillment of disarmament agreements," and become a form of sanctioned intelligence, the Soviets hold to the principle of proportionality between the "means, forms and methods" of verification on the one hand, and the scope of the disarmament measures on the other. "The United States and its allies," Timerbayev argues, "ordinarily advance verification proposals which deliberately go beyond that which is actually required for assuring the fulfillment of this or that specific disarmament measure." Instead, he urges, there must be a strict correlation between each step towards disarmament and the methods used to verify that step. (Timerbayev, 1984, pp. 17 - 19)

These two concepts, i.e., linking verification with disarmament generally, and linking specific verification procedures with the specifics of the agreed arms control regime, are graphically demonstrated by the verification arrangements allowed under the Intermediate Range Nuclear Forces (INF) Treaty. Not only are "intrusive" on-site inspections permitted as the banned missiles are removed from their operational bases and destroyed, but also the Soviets are allowing the United States to peripherally monitor an active Soviet missile production facility. By doing so, the Soviet Union is helping the United States to verify that this facility, which previously produced the banned SS-20s, is not covertly producing new SS-20s (Leggett and Lewis, 1988, p. 412).

Another Soviet verification concept is, according to Timerbayev, the principle of non-interference in the internal affairs of states. "Verification should be carried out in such a manner that its functioning is not directed toward interference in the internal affairs of states." Although this statement may be broadly or narrowly interpreted, it is toward the area of compliance enforcement that it is directed: any unilateral action by the verifying state to enforce sanctions arising from perceived non-compliance is deemed to fall within the realm of this non-interference statement. Preferable from the Soviet point of view is the formation of an international agency under the United Nations Charter with the authority to apply sanctions, but requiring unanimous approval before committing to action. (Timerbayev, 1984, pp. 19 - 22)

Significantly, no arms limitation agreement between the United States and the Soviet Union discusses procedures should one side detect the other in violation of the agreement. Even the Standing Consultative Commission, set up as a result of the SALT I accords, cannot take action on a perceived violation; it serves only as a forum for each side to air its grievances. Any agreement on SLCMs will most likely follow the historical pattern with no compliance enforcement measures being incorporated into the agreement.

Another verification concern of importance to Timerbayev is the use of verification issues for "improper political purposes -- to avoid disarmament or delay the achievement of agreement on specific, urgent arms limitation questions."

Timerbayev's argument is that disarmament and the consequent increase in world security should not be held hostage to the concerns of one nation's political faction's argument whether an agreement is verifiable or not. (Timerbayev, 1984, pp. 28 - 29)

Timerbayev's frustration with the perceived politicization of the verification issue in the American arena can be seen in the following statement:

> The understanding [has] emerged that the objective of verification is to serve as a means of assuring the fulfillment of disarmament agreements. The unquestionable importance of verification of the observance of agreements [has been] broadly recognized. At the same time, it [has become] apparent that verification is only one of the factors affecting the viability and stability of agreements, along with political, military, technical, and other factors (Timerbayev, 1984, p. 30).

Thus, to the Soviets, verification is only one of several means to ensure fulfillment of an agreement. In the United States, verification is viewed as the overwhelmingly important method of ensuring compliance of an arms limitation or disarmament agreement. Consequently, verification becomes a highly charged political issue. The Soviet observer and compliance analyst is less reliant upon verification methodologies than his Western counterpart and consequently, the verification issue is much less politicized in the Soviet Union.

VI. METHODS OF VERIFICATION

This chapter discusses the various methods that have been proposed for verifying a SLCM agreement, if consummated. As discussed in Chapter IV, the three verification issues regarding SLCMs are: (1) establishment of agreed SLCM inventory data bases, (2) the indistinguishability between nuclear and conventional SLCM variants, and (3) the possibility that a conventionally armed SLCM may be converted to a nuclear armed one. These issues are potentially susceptible of solution by seven different verification methods. The first four are concerned with verifying the total number of SLCMs in a nation's inventory; the next two attempt to resolve the concern over the indistinguishability between conventional and nuclear SLCMs, and the final method is aimed at preventing the conversion of conventionally armed SLCMs to nuclear armed, or vice versa.

Each of these methods of verification has been discussed in the arms control literature, but generally as a component of a specific verification regime. The goal in this chapter is to discuss each method individually. Although it is realized that any agreed verification regime will include some, if not all, of these methods, it is hoped that by discussing them individually both the merits and demerits of each may be exposed.

Each method of verification under consideration is examined from three different perspectives: first is a description of the method and how it works; next, the discussion looks at the advantages and disadvantages of each in the verification of a SLCM agreement and finally, the discussion concentrates on what the method may indicate about Soviet <u>compliance</u> with the SLCM agreement.

A. NATIONAL TECHNICAL MEANS

"National technical means (NTM) of verification" have come to be associated primarily with satellite reconnaissance capabilities. The term, however, is much broader than that; NTM include collection capabilities on the oceans, ashore, and in the air, as well as in space. Two categories of NTM which may have the greatest impact on a SLCM verification regime are photo-reconnaissance and electronic intelligence intercept satellites. Only these two categories of NTM are discussed below.

It is recognized that most information on national satellite reconnaissance programs, whether U.S. or Soviet, is highly classified. All information on the systems cited in this discussion is drawn from unclassified sources.

1. Photo-reconnaissance Satellites

Photo-reconnaissance satellites have been used by the United States for intelligence gathering and target mapping purposes since the early 1960s. Use of these assets for arms control verification purposes was first "institutionalized" in the SALT I Interim Agreement. Article V states:

> 1. For the purpose of providing assurance of compliance with the provisions of this Interim Agreement, each Party shall use national technical means of verification at its disposal . . . (Blacker and Duffy, 1984, p. 419).

While early photo-reconnaissance satellites relied upon a camera and film return system, the current generation of satellites make use of an imaging system in which no film is actually carried aboard the spacecraft (Burroughs, 1986, pp. 226-227). The key component of this system is the charge-coupled device, or CCD, which has been described as

> a high density information storage device with a capacity of about 10^5 bits per cm^3. The information, in the form of an image of the scene being observed, is stored as electrical charges under a linear or two dimensional array of closely spaced electrodes (Jasani, 1987, p. 17).

The varying light levels of the scene determine how much charge is deposited upon each electrode, thus creating variations in brightness and darkness in the final image. The system's ability to distinguish between objects, i.e., resolution, is determined by the number of electrodes which are known as picture elements or pixels in the CCD array. A commercial CCD image sensor has been constructed with a 2,048 x 2,048 pixel format (Jasani, 1987, p. 17).

To get the electrical charges of each pixel from the satellite to the ground, imaging satellites must transmit their data streams first to a communications relay satellite which then retransmits the data to a ground site. The relay satellite is required because of the orbital geometry of the imaging satellite; if it is over the Soviet Union, it cannot be in communications "line of sight" with a ground station in the United States. (Burroughs, 1986, p. 227)

What is the resolution of current national level imaging reconnaissance satellites? Burroughs, who arrived at his answer to the question by a combination of "optical science" and "political science," believes the best resolution capability to be in the vicinity of two to four inches (Burroughs, 1986, p. 248). This means objects which are separated by more than four inches are detectable as individual objects.

The greatest advantage of a space based reconnaissance system with regard to verification of arms control agreements is that it is non-intrusive. Although the inspected party may be aware when he is vulnerable to satellite imaging, and although imaging satellites cannot see as many detail features as human inspectors on the surface of the earth, orbital imaging systems have allowed nations to routinely observe and inspect other nations' military facilities, whether for arms control or intelligence purposes, without requiring intrusive, on-site, human observation.

A second advantage of photo-reconnaissance satellites is their ability to cover vast amounts of territory more quickly than ground based inspection teams. One of the gravest concerns in the verification of numerical limits on SLCMs is the possibility of a nation covertly producing unauthorized SLCMs. Imaging satellite reconnaissance systems can greatly ease this concern by being able to search for and locate other sites which may be covertly producing missiles. Arguably, this detection task may be somewhat eased by virtue of the highly structured and centralized characteristics of the Soviet military organization:

> All command organizations, foremost among them the military, follow sets of narrowly defined, carefully established procedures without appreciable variation. That is to say, all military organizations follow rigid patterns in the type and numbers of equipment used, training, support, and operational practices. (Burroughs, 1986, p. 113)

The same may also be said for military hardware construction facilities. Accordingly, since the size, shape and operational patterns for the construction of Soviet SLCMs is probably already known, the detection of another similar, but unauthorized facility, while difficult, is not impossible. If such a facility were detected, and suspicions raised as to its products, challenge, on-site inspections could be used to confirm or rebuke the suspicions.

The drawback to this verification argument is that, while in production, SLCMs are not a resource-intensive system. SLCM production facilities are probably little different from thousands of other light industrial facilities in the USSR. To identify one with enough confidence to recommend a challenge inspection may be analogous to having found the proverbial "needle in a haystack." This is especially important if the number of challenge inspections is limited by the treaty.

A second possible use for imaging reconnaissance satellites is as a tool for counting total SLCM inventories. To fulfill this role, the treaty would have to establish special verification procedures, such as moving SLCMs out of storage facilities periodically, and have them arranged so that the missiles can be individually counted. Although the missiles are small, given the estimated resolution capability of modern satellites, they could be discretely identified.

Unfortunately, use of an imaging system alone to verify SLCM inventory totals may not be sufficient for an accurate and high confidence estimate. First, one could not be sure that all SLCMs in storage were removed and exposed. The missile is small and may be easily concealable from satellite-based sensors. Additionally, there is the problem of missiles deployed aboard operational fleet units. They too cannot be counted by an imaging system alone. Another concern is the possibility of Soviet use of maskirovka techniques to deny information to or to deceive American verification analysts.

Photo-reconnaissance satellites alone can provide little information for the determination of compliance to a SLCM agreement. While limited in the ability to count and identify individual SLCMs in the attempt to obtain an inventory count, the imaging system is valuable for the purpose of broad area searches; detection of suspicious activity and/or signs of maskirovka could then cue the application of other "higher-resolution" verification methods. This broad area search capability may be the most useful attribute of an imaging satellite in a SLCM verification regime.

2. Electronic Intelligence Satellites

Electronic intelligence (ELINT) satellites are the second category of satellite-based national technical means of verification that may be useful in ensuring SLCM treaty compliance. Actually, ELINT satellites comprise only one-half of the broad category of signals intelligence (SIGINT) satellites. Communications intelligence (COMINT) satellites, whose primary mission is to collect and relay communications-related signals for later analysis, comprise the other half. COMINT satellites are excluded from this discussion as SLCMs do not "communicate" in the traditional sense of sending data from one location to a receiver at another location.

ELINT satellites may be used in a SLCM verification regime to assist the photo-reconnaissance satellites in the detection and inventory-accounting of long range SLCMs. These satellites are designed to detect a wide range of electronic emissions, and are particularly targeted against radar signals. Verification assistance may be obtained through the intercept of the emissions from a missile radar altimeter during an operational test. By detecting a radar altimeter emission from an in-flight missile test, one can be sure that one airframe has been removed from the inventory. Even if the test missile were not armed, the airframe would probably be destroyed upon impacting the target.

The drawbacks to this method of inventory-accounting are manifold. The primary one is that this method relies upon the interception of a signal which may be too weak to detect. SLCMs fly very close to the surface of the earth, which means that the power requirement for a radar altimeter need not be very great and the resultant emissions quite weak. Also, one cannot assume a perfect reflection of the radar signal off the surface; a mixture of scattering and absorption of the incident energy is unavoidable. Finally, the orbital mechanics of the satellites may make the collection of such a weak signal impossible. ELINT satellites at geosynchronous orbit may be too distant to detect the reflected energy, while those in low-earth orbit may not have the dwell time or orientation to intercept the radar altimeter's reflection.

Operational or test firings of SLCMs provide compliance evaluators with a unique challenge if the treaty sets a maximum limit on a SLCM inventory. Presumably each missile fired, for whatever purpose, is replaceable by new production so as to keep the allotted inventory at full strength. Compliance evaluators must be able to correlate the number of SLCMs produced with the number of missiles fired in addition to those which have reached the end of their service lives, or are accidentally damaged. In order to keep an accurate "balance sheet," SLCM firings must be detectable; if not, one cannot be sure whether SLCM production has not generated an "excess" of weapons. Although this possibility has not attracted the attention of other authors, detection of fired missiles by satellite based electronic intercept offers one potential solution to this verification concern.

B. DATA EXCHANGES

The second broad verification method discussed in regard to SLCMs is the exchange of data among the signatories; its purpose is to establish current SLCM inventory "baselines." The procedures for these, and subsequent, exchanges should be a component part of a treaty. Baseline inventory data bases are a "must" for any treaty limiting the total number of SLCMs since it is from these baselines that current SLCM inventories will change to approach their agreed maximums. Specifically, there are four data items that must be exchanged for verification or compliance assessment. The first one is a tally of the number of missile airframes available to a nation, including not only those in an operational status, but also those in test and evaluation, research, or storage. The goal is a count of all airframes that could, if necessary, be converted into an operational missile.

After the current inventory baselines are established and agreed upon, it is necessary to know how that inventory changes, whether through addition (i.e., new production) or subtraction (i.e., operational tests). The second required data set, the number of missiles being produced for either repair or replacement, solves one-half of this problem. The problem of inventory reduction has been discussed above. The final two required data sets relate to verification of submitted inventory information, namely the location of (1) SLCM production and repair facilities, and (2) location of SLCM storage facilities.

The primary advantage derived from these data exchanges is that each signatory has in its possession a working data base of the other's total SLCM inventory. As this inventory changes due to additions or deletions, subsequent data exchanges are used to periodically "balance-the-books."

Unfortunately however, this verification method cannot ensure against outright lying and falsification of data base information. It is for this reason that one must have the ability to verify that the data received are indeed correct to begin with. Furthermore, this method does not address the problem of covert production or storage of SLCMs since, after all, such information would not be a part of the exchanged data. If judged to be accurate, however, exchanged data bases can be a powerful tool in the evaluation of treaty compliance, at least for the total number of missiles in the inventory. Although one must continue to be on guard against covert production, accurate data exchanges can help reduce the suspicion of covert production and storage.

C. ON-SITE INSPECTIONS

The next verification method, on-site inspections (OSI), has received a great deal of attention during the past 18 months. This attention is largely attributable to the Intermediate Range Nuclear Forces (INF) Treaty signed in December 1987. This was the first arms control treaty that permitted the use of on-site inspection (OSI) procedures in the signatories' nations. (Leggett and Lewis, 1988, p. 410)

In a SLCM agreement, OSI may fulfill three requirements for effective verification of SLCM inventories. The first is for the periodic inspection of SLCM production, storage, repair and deployment facilities. Such inspections are intended to give the inspecting team knowledge of the available SLCM storage capacity and the rate at which new SLCMs could be produced. A second requirement would be knowledge of the destruction of no-longer operational missiles. The problem of depletion of SLCM inventory by flight testing has been discussed above. It may be necessary to allow inspectors to be present at flight tests to observe this form of inventory reduction. Production and destruction monitoring as described above would be necessary to maintain strict SLCM inventory accounting.

Finally, an OSI verification regime must have the capability to initiate challenge on-site inspections. Without such inspections, the covert production and storage problem remains. Satellite reconnaissance systems may be able to identify sites suspected of covertly producing SLCMs, but without challenge OSI one can neither confirm nor disprove the suspicions.

How would such a verification regime work? If one assumes only on-site inspections, including challenge inspections, were agreed to as the verification method, designated inspectors would travel to the agreed facilities for activity monitoring. Unfortunately however, only a limited number of individuals would presumably be allowed to inspect these facilities. One study estimated that a typical on-site inspection team, designed to verify a comprehensive test ban treaty, would require a minimum of nine inspectors and eleven support personnel at each facility (Krass, 1985, p. 220). In another example, the U.S. On-Site Inspection Agency has approximately 200 individuals assigned to the Soviet Union for the verification of the INF Treaty, exclusive of those assigned to perimeter portal monitoring duties (Leggett and Lewis, 1988, p. 410). Although a SLCM inspection team probably may not be as large as one monitoring a comprehensive test ban treaty, fewer inspectors per site will face a greater reliance upon the host country for assistance and support in completing the monitoring process.

One concern in the operational use of OSI is the degree of latitude inspectors will be given to "roam" about a facility during an inspection. Essentially, this is a question of what can be considered within the purview of the inspectors. Naturally, the inspection team would like to have complete freedom to move about a facility to observe its operations. Conversely, the host country is sure to want to restrict movements in order to limit the amount of collateral intelligence the inspection team might gather. Additionally, many, if not most, defense industry production and storage facilities are multi-purpose, so that systems not covered under the treaty are liable to be present, yet to which the inspectors have no need for access. This is a concern for resolution at the negotiating table, although solutions reached on paper cannot ensure compliance with those words in actuality.

There are three primary advantages to on-site inspection for SLCM verification. First, the inspecting nation need no longer rely exclusively on data provided by the host government. Secondly, and as a corollary to the first, human observation can offer a degree of confidence above and beyond that afforded by automated means. No matter how high the quality of imagery from photo-reconnaissance satellites, it cannot provide a close-up view of the facility, nor obtain the impression of capabilities that an on-site inspector may obtain. One should never underestimate the value of the human senses in developing an impression regarding compliance. Although governments may not charge a violation based on "impressions" alone, they may provide useful "clues" for further investigation.

Lastly, challenge inspections can deter cheating on a SLCM agreement. The possibility, even though small, that a challenge inspection may uncover a "smoking gun," may have a high deterrent value against the side that contemplates cheating. (Shearer, 1984, p. 29)

Another minor advantage to on-site inspections is that they are less expensive to run, for the amount of data returned, than other verification methods, particularly national technical means. On-site inspections may also preclude the implementation of complicated and extensive procedures to make verification by national technical means possible. (Shearer, 1984, p. 29)

The greatest potential drawback to on-site inspection is the possibility that on-site inspection locations may draw concentrated effort at maskirovka (Harris, 1987, p. 187). Maskirovka has been variously defined in Western literature, but succinctly defined, it is "the art of masking by means of denial and deception activities" (Harris, 1987, p. 186). While it may sound counter-intuitive to expect maskirovka activity during an on-site inspection, one must remember that arms control treaties cover specific weapons systems. In the attempt to verify compliance with those treaties, the intelligence community generally, and the on-site inspectors particularly, may become (overly) focused on the covered systems to the neglect of other requirements. Maskirovka activities may or may not be conducted in regard to treaty limited systems, however, maskirovka activity regarding noncovered systems may provide adequate cover and deception for some other military capability.

Another OSI drawback may be that the resources expended for, and emphasis placed upon, this method may draw time and effort away from other methods of intelligence data collection used in the verification process. In particular, the requirement for photo-reconnaissance satellite imagery of the inspected facilities may be down-graded in importance. There may be the temptation to conclude that since a site is already being observed by inspectors on the ground, the highly valuable imaging time of a satellite transiting over the Soviet Union should be used for other, non-observed sites. Imagery taken during an inspection, however, may be the sole means of determining what has changed at that site for the inspection team's visit, and thus may be the sole means to detect maskirovka activity.

The final drawback to on-site inspection is that a limited number of challenge inspections constrains the ability to confidently verify the treaty's provisions, particularly in the case of SLCMs. As discussed above, imaging systems may be able to detect possible production facilities which appear to violate the treaty, but without challenge inspections, little may be done to alter the situation.

There is, moreover, an argument opposing the concept of challenge OSI. This argument turns on the concern that, challenge OSI being reciprocal, it could be used for improper intelligence purposes, particularly by the Soviet Union's inspectors in the United States. Facilities which are obviously not engaged in the operational life of a SLCM could be challenged, possibly opening the door to an intelligence coup. The Soviets could, for example, challenge that Electric Boat Company, in its Groton, Connecticut covered construction hall, was covertly producing SLCMs and storing them aboard new-construction submarines. Such a challenge would send nervous shudders throughout the Navy. Certainly, without some method of vetoing challenges, and possibly even with such a veto, the stage could be set for challenge inspections to become intelligence gathering, rather than verification, missions.

Additionally, most, if not all, defense research and weapons production in the United States is contracted out to private firms, so that challenge inspections could raise complicated legal questions over corporate privacy and proprietary rights. Challenge inspections cannot be permitted to interfere with the rights of individual or corporate privacy enjoyed by Americans and American businesses. The government's right to demand access to private corporate facilities is very limited, and most likely would have to be agreed to contractually. This is not a simple issue, although it has received virtually no coverage in verification literature.

What OSI can provide is deterrence to ensure compliance. Even if the host nation engages in <u>maskirovka</u> activity, its country's leadership can never be certain that the whole <u>maskirovka</u> curtain will not come unravelled, exposing their non-compliance, not only to the inspecting party, but also to the world. Secondly, OSI allows the inspecting party to be responsible for its own data collection without having to rely upon the good faith (and data) of the party being inspected.

D. PERIMETER PORTAL MONITORING

The final verification method which has been advocated as a method of maintaining a reliable count on SLCM inventory is perimeter portal monitorings (PPMs). PPM "involves setting up inspection stations at the perimeters of facilities which are 'choke points' in the path a weapon follows from production to deployment" (Harvey and Ride, 1988, p. 5). Ideally, the goal is to monitor the flow of each weapon as it transits between each stage in its operational life, from production to destruction. Such monitoring would allow --

assuming the accuracy of the baseline data -- an accounting of all the numbers of weapons in a SLCM inventory at any time. Thus, PPM could be a highly effective verification method if a treaty only limited the total number of SLCMs permitted to each side.

To achieve this high confidence level, perimeter monitorings would have to be continuous, 24 hours a day, 365 days a year, at the entrances and exits of all the "choke points." To do otherwise would be to introduce the possibility of error, since during the non-monitored times, missiles could be moved from one location to another or unaccounted missiles deployed. The greatest advantage of the PPM concept is that it allows the inspectors to keep an accounting on all the legal SLCM storage and production rates without being too intrusive. PPMs do not require the inspectors to enter into any of the missile facilities but only to intercept the movement of weapons in and out of those facilities. In this respect, PPM may be considered a "passive" verification procedure in the sense that it cannot verify anything unless the host country moves one of its missiles.

A second advantage of perimeter monitorings is that if a nation wanted to obtain a covert supply of SLCMs, it would be required to create an entirely new set of facilities to cover the operational life cycle requirements of the covert missiles. The creation of these new facilities would not be an inexpensive operation. Its cost would be justified, however, if the national leadership believed the risk of detection was low and the additional military capability provided by the covertly produced SLCMs high.

Of course, the inspecting nation must constantly guard against the possibility of a covert production, storage, and deployment path. The inspectors do have one advantage in this regard, though. In a PPM verification regime, the inspecting nation already has available knowledge of what the operational life cycle of the missiles entails and an appreciation of the types of facilities used in that cycle. Knowing, as discussed above, that military organizations tend towards uniformity in their operations, a secondary, illegitimate SLCM production facility can reasonably be expected to resemble the legitimate original. Thus, a search process for covert SLCM facilities may be narrowed down to sites whose activities closely resemble the allowed SLCM facility.

One final advantage of PPMs is a national security consideration. With this method of verification, inspections aboard ships are not required to maintain the inventory data base. Although naval facilities themselves would be candidate PPM sites, no individual ships need be inspected. Once a missile entered a naval facility, it could be considered "deployed," regardless of whether or not it was actually placed aboard a ship. Such perimeter monitorings would preserve the American commitment neither to confirm nor to deny the presence of a nuclear weapon aboard a ship.

The greatest drawback to PPM is a consequence of its great advantage: the requirement for continuous monitorings. It has been shown how continuous monitoring is necessary to ensure that no covert missiles are produced or transferred from one location to another. All shipments going into or departing from these facilities, some of which serve a multitude of purposes, would be subject to inspections. Again, as with on-site inspections, there is the problem of the inspectors having access to non-treaty controlled items. There is no easy answer to this dilemma of preserving one's military security while still allowing perimeter portal monitorings in the search for transiting SLCMs.

For compliance purposes, continuous PPMs could provide a strong deterrent against cheating and covert production. Not only would it be difficult and costly to establish a second production-to-destruction cycle, but one would also constantly risk exposure and opprobrium in return for a limited gain in military capability. Also, the fact that the more extensive the violation, the greater the likelihood of being discovered, must occur to the national leadership before ordering the covert production of SLCMs. Thus, perimeter portal monitorings may provide a high degree of deterrence against cheating because, if used in conjunction with the broad search capabilities of photo-reconnaissance satellites, they offer a high probability of detection.

The four preceding verification methods, namely, national technical means, data exchanges, on-site inspections, and perimeter portal monitorings, have been proposed in the attempt to solve the problem of accounting for the total number of missiles in a treaty-controlled SLCM inventory. These methods emphasize the total number of SLCMs available and do not attempt to distinguish between individual varieties of missiles. To verify a qualitative, i.e., nuclear armed SLCM inventory sub-ceiling, it is necessary to be able to identify the particular warhead type carried on each individual missile. Two verification methods have been proposed to solve the problem of distinguishing between the conventional and nuclear variants of sea-launched cruise missiles. They include "tag identification" and "nuclear material identification."

E. TAG IDENTIFICATION

The primary purpose of the tag identification method is to distinguish the conventional and nuclear variants of SLCM. To be effective, the tags must be tamper-proof, unduplicable, environmentally stable, and not interfere with the operational capabilities of the missile (Leggett and Lewis, 1988, p. 422; Harvey and Ride, 1988, p 5).

Proposed methods of tagging SLCMs have been categorized as either "passive" or "active." Passive tags "do not produce their own identification," but require an inspector to use some proactive device to obtain the identification. "'Active' tags provide their own identification," and require only that the inspector read the information from the tag which can then be correlated to the identification of a specific missile. (Leggett and Lewis, 1988, p. 422) Two candidate tagging options, one passive and involving the use of metal flake paints, and the other active through the use of an electronic code box, are discussed below.

The passive tag identification method proposes to use metal fleck paints and photomicrography techniques. Each missile would have painted on it a small area with imbedded "glitter" particles, the "glitter" being the imbedded metal flakes. The missile and tag are then photographed under a number of lighting variations, so that the recorded glitter reflections provide a unique identification for that missile. Warhead information on each missile would have to be provided, or determined independently, and associated with the tag identification. During subsequent inspections, the tag would be re-photographed. When the new photographs are compared with the originals, any variations will supposedly be detected. Detected tag anomalies could be an indication of attempts to modify that missile. Since a specific warhead would be associated with specific tags, an inventory record of nuclear armed SLCMs could be maintained. (Plyler interview, 1 February 1989).

The use of an electronic tag has also been proposed as an active device in the verification of a sub-ceiling on nuclear armed SLCMs. According to this scheme "each tag would incorporate a unique, encrypted code so that a digital input would produce in response a unique digital output known only to the nation installing the tag . . . (Tsipis, April 1988, p. 13). Such a procedure would uniquely identify the missile only to the inspecting nation. The encryption tag would be unduplicable as well as tamper-proof; tampering would destroy the tag, thus baring strong evidence of an attempt to deceive the inspectors. Additionally, a destroyed tag might be regarded as an attempt to pass an illegal missile as a legal one, providing further evidence of possible intent to deceive. Both passive and active tagging methods could be installed as the missiles pass through the first perimeter portal monitoring location at the exit of the production facility.

One large advantage of a tagging regime such as the one described above is that it could solve the problem of nuclear/conventional warhead accountability without relying upon actual access to the warhead. Of course, the type of warhead on each missile would still have to be declared or determined, and then verified, when the tag is applied, but afterward no further access to the warhead would be required. Periodic reconfirmation of the warhead type would deter conversion of missiles from conventional to nuclear.

The argument against a tagging regime stems from the belief that there is no such thing as a non-reproducible, tamper-proof tag. The fear is that tags could be reproduced to make excess missiles appear "legal," thereby providing the nation in violation with an additional military capability. To this author, however, such fears are unfounded. Even if the tag were reproduced and attached to a non-legal SLCM, a reliable and accurate inventory accounting procedure would rapidly identify the discrepancy in the inventory totals. A nation wanting to have a covert SLCM capacity would want to hide these weapons, not bring them to the inspectors.

Tag identification methods can assist the inspector in ensuring that the nuclear SLCM inventory in particular, and the total SLCM inventory in general, do not exceed agreed limits. While this capability is valid only for "legal" SLCMs, the tagging process also helps deter illegal SLCM production. This is so because any SLCM discovered external to the production facility without a tag could be considered an illegal missile and thus in violation of the treaty.

F. NUCLEAR MATERIAL DETECTION

The second proposed method of identifying nuclear SLCMs involves the attempt to classify the warhead by the knowledge and use of the physical properties of nuclear materials. As with tags, active and passive methods of nuclear material detection have been suggested in the open press:

> Passive methods make use of the natural decay processes characteristic of all radioactive materials. These decays result in the emission of various nuclear radiations, but only the neutral particles emitted will have a substantial probability of being detected at some distance from the radioactive material. (Gsponer, 1983, p. 210)

The two neutrally charged spontaneous emissions from nuclear weapon materials are gamma rays and neutrons. Portable devices to detect these two emissions have been produced (Gsponer, 1983, p. 212).

Active methods require the irradiation of the warhead with neutrons or gamma ray beams to,

> induce various nuclear reactions inside the fissile material. The neutrons and gamma rays from the induced reactions may then be recorded by detectors similar to those used in the passive methods. (Gsponer, 1983, p. 213)

Another active method proposes the use of low-power x-rays to irradiate the missile warheads. Unlike neutron or gamma ray interrogation, the x-ray technique does not interact with the nuclear material to produce an emission. Instead, this method exploits the physical property whereby the absorption of x-rays varies with the Z-value (i.e., the size of the nucleus) of the material through which it passes. Thus, "x-rays will be attenuated much more strongly by the high-Z materials of a nuclear warhead than the low-Z ordinary high explosives of a conventional warhead" (Tsipis, 1988, p. 50).

The primary concern in nuclear material detection is the possible use of shielding to prevent detection of the spontaneous nuclear emissions. "In principle, it is possible to design shields that would easily make it impossible to detect nuclear weapons of all kinds behind them, either by active or passive methods" (Gsponer, 1983, p. 213). There is a cost one pays for such protection though, ". . . effective shielding can only be obtained by the addition of considerable weight and volume" to the warhead assembly (Gsponer, 1983, p. 214). Assuming a constant volume for the guidance and propulsion components, any mass and volume dedicated to shielding would penalize the mass and volume available for the warhead. Whether this interplay can result in a shielded and completely non-detectable nuclear armed SLCM remains an open question.

Additionally, either active or passive nuclear detection may identify more about the warhead than just whether it is nuclear or not. Gamma ray emission rates are characteristic of the size and composition of the warhead. Active x-ray procedures can detect the Z-value of a material precisely. These detection capabilities may be used to identify the composition of the nuclear warhead and thus its probable yield. Consequently, nuclear detection methods could reveal intelligence data above and beyond those required for treaty adherence verification.

G. SEALS

The first four methods of verification discussed above are concerned with identifying and verifying the total number of SLCMs available to a nation. The next two methods are concerned with identifying and verifying the types of warhead carried by the SLCM, either conventional or nuclear. Finally, "sealing" has been proposed as a verification technique for preventing the conversion of a conventionally armed SLCM into a nuclear armed one. (Harvey and Ride, 1988, p. 5)

The primary driving consideration behind seals is the fear that a nation could "break-out" of an agreed sub-limit on nuclear armed SLCMs by converting conventionally armed missiles to nuclear armed ones. It has been suggested that a seal could be applied to the missile at the first perimeter portal monitoring site immediately following production as part of the same inspection cycle when an identifying tag is applied, and the warhead composition is confirmed by nuclear detection techniques. Any seal must be proof against conversion of the missile's warhead, but not be an interference in the routine maintenance and transport of the missile.

Two approaches have been advanced to create a seal that could meet these requirements. The first is the application of a two-dimensional decal to the missile which would cover the jointure between the warhead/nose cone and the body of the missile. Imbedded metal flake glitter paints used in a manner similar to the tagging scheme discussed above (Plyler interview, 1 February 1989) and holograms (Harvey and Ride, 1988, p. 5) have been suggested to fill this role. With either of these seals, maintenance to the warhead could occur through the use of an access panel. Attempting to covertly replace one warhead with another, however, would break the seal and thus indicate an attempted violation.

Another suggested seal device is the use of a "special kind of fibre optic seal. The best seal would be a net completely surrounding the missile, woven by a single strand of optical fibre . . . " (Tsipis, 1988, p. 50). Again, the goal would be to have the net arranged to allow the maintenance of the missile, but to prevent replacement of the warhead. Additionally,

> somewhere along its length the [fibre optic] strand would be integrally and inextricably connected to a photonic or electronic microcircuit designed to receive a coded digital input through the fibre. By means of a unique and reprogrammable code contained within it, the microcircuit would transform the input signal to a photonic digital output identifying the particular net (Tsipis, 1988, p. 50).

Thus, verification that the net has not been cut and the warhead converted, becomes simply a matter of inputting a signal into the fiber optic strand and receiving an output back. If no output signal is returned, then it would be known that the strand had been broken in some way.

The advantage of both of these seal methods is their sensitivity to any minor changes in the missile's physical configuration. Unfortunately, this sensitivity also makes these seals vulnerable to the routine minor damage any weapon may be expected to undergo during normal handling and maintenance. A tightly woven fiber optic net around the missile would be particularly vulnerable to damage. Even a missile in a canister cannot escape the jostling of routine transport or loading aboard a ship. Without a more durable seal, the likelihood of a "false positive" is probably high.

A second advantage to a workable seal is that the seals could be applied and monitored at the perimeter portal monitoring facilities. As with the identifying tags, there would be no need for inspectors to access ships, helping to preserve, in the U.S. Navy's case, its NCND policy.

The largest drawback to a seal is that it may not be able to prevent the use of insertable nuclear components to convert the warhead of a SLCM from conventional to nuclear. As discussed in Chapter IV, insertable nuclear components have been proven feasible for a torpedo-sized weapon. Since access to the missile must be allowed for maintenance purposes, it may not be possible to ensure that such access would not also permit the installation of a nuclear component.

Nevertheless, with the resolution of the problems of seal sensitivity to damage and the use of insertable nuclear components, this verification methodology could become a useful means for the prevention of warhead conversion on SLCMs. The proposed seals do not require inspectors to access to the warhead and may be applied at already established perimeter portal monitoring sites, thus reducing the "intrusiveness" of this method of verification.

VII. CONCLUSION

This paper has presented the views of senior officers of the United States Navy on why sea-launched cruise missiles should not be included in the current strategic arms negotiations. This argument is supported by three legs, namely, (1) the military utility of the nuclear armed Tomahawk SLCM, (2) the relationship between conventional and nuclear variants of Tomahawk, and (3) the impossibility of adequately verifying a SLCM agreement. In this argument, Tomahawk is militarily useful across a range of tactical to strategic missions. Strategically, SLCMs are believed to add to deterrence by distributing nuclear delivery systems among a wide range of platforms. In the NATO theater, SLCMs are viewed as a valuable link in the strategy of flexible response, possibly serving as a replacement for the now banned ground-launched cruise missile and the Pershing II intermediate range ballistic missile. On a tactical level, it is argued that the combination of conventionally armed Tomahawk and naval air striking power has "revolutionized" war at sea.

The physical similarities between the Tomahawk variants, whether land attack or anti-ship, nuclear or conventional, has also been used in arguing against SLCM arms control. Since proponents of this argument have assumed that conventionally armed SLCMs should (or must) not be included in "strategic" arms control negotiations, the indistinguishability between the conventionally and nuclear armed SLCM variants renders any nuclear SLCM accounting scheme useless, and thus an agreement unverifiable. But the indistinguishability issue is not the sole verification problem. Additionally, proponents have argued that the missile's size and its ease of manufacture could allow for the covert production and storage of excess SLCMs and that one cannot ensure that conventionally armed missiles are not converted to nuclear armed ones.

From a technological standpoint, however, this anti-verification argument is weak. The author has presented above seven different verification methods which address the Navy's verification concerns. Although none of the different verification routines and methods discussed in this paper is sufficient by itself to guarantee a "cheat-proof" SLCM agreement, in combination they can offer a synergistic, mutually supportive, high-confidence verification regime. Even if the verification routines mentioned in this paper are not acceptable to the American arms control community, other routines have been suggested in the verification literature. Essentially, the SLCM verification question is a technical problem, and a solvable one.

Of course, there are political aspects to verification, too. The answer to the question of what comprises "adequate verification" is reached at the highest level of the American government, between the President and the Senate. If one is from the "substantive" school of verification, a verification regime probably can be readily achieved. Conversely, if one adheres to the "legalistic" school, then a satisfactory verification regime may be impossible. Regardless of where one stands on this issue, the decision on verifiability is ultimately a political one that will be made in a political context, encompassing a wide range of political issues that may or may not have a direct relationship to national security policy. When, and if, the President outlines his vision of adequate verification, and if that view is accepted by the Senate, then the Navy might be forced into SLCM limitations.

To preclude this situation, the Navy's leadership must continue to stress the military, including strategic, theater and tactical value of both conventional and especially nuclear SLCMs while more deeply analyzing in what manner Tomahawk, and its carrying platforms, would execute these missions. Although the statement that by constituting "a flexible, mobile system, dispersed throughout the world's oceans, SLCMs defeat Soviet targeting in advance," thus providing "a credible and significant component of nuclear deterrence" (Mustin, 1989, p. 186) may read well on the pages of International Security, there are grave issues which must be addressed before this statement can truly become an operational reality.

For example, if one places a nuclear armed Tomahawk in the nuclear reserve force, "that part of our nuclear forces designed to be withheld to deter a follow-on attack against the United States and its allies" (Brooks, 1989, p. 171), one must answer the question of how that unit which is carrying that Tomahawk will be operationally employed. Under whose operational control will that ship or submarine operate during the time its missiles are within range of the Soviet Union? Will she have to go to sea on "alert," similar to ballistic missile submarines? What effect will such a policy have on the operational flexibility of the ship, both in regard to other missions and especially the "neither confirm nor deny" policy? If a ship goes on deployment as an identified component of the strategic nuclear reserve, the NCND policy will have been violated. A parallel set of questions must also be asked and answered if Tomahawk is to be utilized as a NATO replacement for the "Euromissiles."

In conclusion, verification of limitations on sea-launched cruise missiles has both political and technical components. Politically, the question of verifiability is likely to be decided on grounds other than purely "technical" ones. From another standpoint, maintaining a SLCM inventory account, distinguishing between conventionally and nuclear armed SLCMs, and preventing the conversion of conventional to nuclear warheads is probably technologically feasible. If the Navy wants to prevent limitations on its planned sea-launched cruise missile inventory, then it should downplay its arguments against the verifiability of a SLCM agreement, a decision which it alone cannot control. It ought to concentrate its efforts instead on emphasizing the weapon's contribution to the Nation's national security.

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