Cruise Missile Arms Control

Robert J. Lempert
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Robert J. Lempert

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PREFACE

The treatment of long-range, land-attack, sea- and air-launched cruise missiles is one of the major stumbling blocks in the current START negotiations. The existence of both conventional and nuclear variants is an oft-mentioned reason, since it is impossible to distinguish the two types except by close inspection. However, a more fundamental problem is that cruise missiles are carried by platforms—ships, submarines, and bombers—that have many important roles, mostly unrelated to nuclear capabilities that are the subject of START.

This report examines options for controlling both air- and sea-launched cruise missiles within strategic arms control treaties. These options are assessed by the extent to which they provide easily verifiable limits on nuclear cruise missiles, allow substantial deployments of conventional cruise missiles, and avoid operational restrictions on conventional military forces. Recommendations are made regarding which options the United States might attempt to achieve. This work was supported by The Ford Foundation and by The RAND Corporation with its own funds. It was produced under the project entitled Cruise Missile Arms Control.
SUMMARY

This report assesses options available to the United States for negotiating limits on sea- and air-launched cruise missiles (SLCMs and ALCMs). Within START, the primary U.S. interest is to obtain Soviet agreement on limits on other types of weapons. Only secondarily is the United States interested in restricting the number of Soviet nuclear cruise missiles. Therefore, the United States should aim for an agreement that allows large deployments of conventional cruise missiles, avoids operational restrictions on military forces, and is not too costly to verify.

Cruise missile arms control options can be usefully divided into three categories: deployment limits restricting the cruise-missile-capable launchers that can legally carry nuclear cruise missiles; launcher limits restricting the number of cruise-missile-capable launchers; and inventory limits restricting the number of cruise missiles (or other treaty accountable items) each side can legally possess. Inventory limits can either have simple, and thus not costly, verification schemes that make no attempt to detect production and storage of cruise missiles from undeclared facilities, or they can have stringent and costly verification designed to detect (and hence deter) such activities.

These options could be combined to restrict nuclear cruise missiles on bombers, surface ships, and submarines.

The START framework counts bombers that carry nuclear cruise missiles against the START nuclear warhead and delivery vehicle ceilings. Dedicated conventional bombers are allowed, but it is not clear what weapons they could legally carry. To allow conventionally armed cruise missiles, the treaty should prohibit the deployment of nuclear weapons on these aircraft but allow any type of conventional weapon. Short notice on-site challenge inspections would certify that these conventional bombers were not nuclear armed. Separate ceilings on the number of permitted dedicated conventional bombers would restrict the potential for a breakout, in which one side overtly violates the treaty by rapidly deploying illegal cruise missiles.

The treaty should either ban the deployment of nuclear cruise missiles on surface ships or allow them to carry only properly tagged cruise missiles. These provisions could be verified by inspections of SLCM-capable launchers while the ships are in port. Equipment
capable of reloading these launchers at sea would be banned, or the inspections would have to include magazines as well. Such a scheme is vulnerable to breakout, but breakout can be made more difficult, although not prevented, by simple inventory limits on nuclear cruise missiles. However, so long as the treaty permits a few hundred nuclear SLCMs on submarines, a breakout of ship-launched SLCMs is not of sufficient concern to the United States to warrant more stringent SLCM controls or to give up the other benefits of START.

For submarines, the treaty could ban nuclear or untagged SLCMs in vertical launch tubes and ignore any SLCMs carried for launch through the torpedo tubes. The first provision could be verified by import inspection of the vertical launch tubes. The latter provision may be sufficient because submarines can carry only limited numbers of SLCMs. Their magazines are small and mostly filled with other necessary weapons, such as torpedoes. Alternatively, the treaty could ban untagged SLCMs from submarines. Such a provision could be verified by inspections of the weapons being loaded and unloaded from submarines in port. In other particulars this scheme is similar to the deployment limits for surface ships. None of these options prevent breakout, but as in the surface ship case, this drawback is not important as long as a few hundred nuclear SLCMs are allowed on submarines.

If the United States and Soviet Union pursue strategic nuclear arms limitations to ceilings substantially below those in START, preventing a nuclear cruise missile breakout will eventually become a serious concern. Such a treaty would have to either restrict the number of cruise-missile-capable launchers (including torpedo tubes and all cruise-missile-capable heavy bombers) or apply stringent inventory limits. To be worth the effort, a stringent inventory limits regime must restrict conventional cruise as well as nuclear missiles. Neither these launcher limits nor stringent cruise missile inventory limits would permit large deployments of conventional cruise missiles. Further, inventory limits on conventional cruise missiles would be exceedingly difficult to verify.

A potential alternative is inventory limits on nuclear warheads and materials, which may be easier to verify than cruise missile inventory limits and might obviate the need for restrictions on not only conventional cruise missiles, but the full range of dual-capable platforms, in a treaty with very low ceilings on strategic nuclear weapons.
ACKNOWLEDGMENTS

I want to thank RAND colleagues Glenn Buchan, William Harris, Edward Harshberger, David Ochmanek, and Timothy Webb for helpful comments and criticisms on the drafts of this report. In addition, I am grateful to Commander Bradd Hayes, RAND's Navy Research Fellow for 1988–89, who gave generously of his time and effort in helping with the research for this work.
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I. INTRODUCTION

From its introduction in the late 1970s, the modern cruise missile has become an increasingly important component of the U.S. military forces. These small, long-range, unmanned air vehicles are an important response to the growing cost of manned aircraft and the increasing lethality of the world's air defenses. Modern cruise missiles were first developed to carry nuclear weapons. The U.S. Air Force began deploying them on B-52 bombers in 1982 as a fairly inexpensive means of bolstering the air-breathing leg of the strategic nuclear triad, and the U.S. Navy is currently arming ships and submarines with these weapons. In the last several years, conventionally armed cruise missiles have also been heralded as an important contribution to U.S. defenses. These weapons, made possible by advances in highly accurate guidance technology, could enhance the balance of conventional forces with the Soviet Union as well as allow the United States to project air and naval power against other potential enemies. The Soviet Union also has a modest program of air- and sea-launched nuclear cruise missiles (ALCMs and SLCMs), but has revealed no interest in conventionally armed systems.

The cruise missile is also perceived, with much justification, as a serious arms control problem. The existence of both conventional and nuclear variants is a reason frequently mentioned since it is impossible to distinguish the former from the latter except by close inspection. However, a more fundamental problem is that air- and sea-launched cruise missiles are carried by platforms—ships, submarines, and bombers—that have a multitude of roles often unrelated to their long-range nuclear-attack capabilities. For instance, the battleships, cruisers, and destroyers that carry the U.S. Navy's nuclear and conventional cruise missiles have missions ranging from showing the flag and protecting sea lanes to limited nuclear strikes. Although these multipurpose platforms are militarily desirable, they pose a problem for those trying to craft an arms control regime. The main technique for establishing arms control ceilings on strategic nuclear weapons has usually been to construct counting rules based not on the weapons themselves, but on the

platforms needed to deliver them. Past treaties have controlled ballistic missile warheads by limiting the number of ballistic missiles in silos. The advantage of this method is, clearly, that missiles in silos are easier to find and count than are the nuclear warheads themselves. However, the number of cruise-missile-capable naval vessels and aircraft cannot be limited without severely restricting their ability to carry out their numerous nonnuclear missions.

An alternative to controlling platforms is to limit the number of cruise missiles themselves. But verifying such limits would be particularly difficult because these weapons are small and easily hidden. A typical cruise missile is about 6 m long and weighs 1000 kg. It can be manufactured and stored in facilities indistinguishable from many other light industrial complexes. Its test flights can easily be covert. In contrast, a ballistic missile with similar range weighs about 15,000 kg and, being filled with highly volatile fuel, must be manufactured and stored in special facilities. Its tests produce beacons of light and heat readily detectable from space.

The START treaty currently being negotiated between the United States and Soviet Union will probably treat both air- and sea-launched cruise missiles. The two sides have agreed on a framework for the former. The approach is similar to the traditional one and is based on segregating bombers into separate classes, each dedicated to carrying different types of weapons—nuclear long-range cruise missiles, nuclear short-range bombs, and conventional weapons. Each class of bombers will be assessed differently against the treaty's ceilings on warheads and delivery vehicles. Several serious issues remain; in particular, it is not clear whether the current framework would permit substantial deployments of conventional ALCMs. On the subject of SLCMs, the two sides have agreed only that such missiles will be limited but will not count against the main treaty ceilings. The United States has recognized no scheme for limiting cruise-missile-capable naval platforms. Much of the debate has concentrated on the prickly complications of verifying the location or production of the cruise missiles themselves.

There are several options available to the United States in negotiating limitations on sea- and air-launched cruise missiles with the Soviet Union. These options can usefully be divided into three general categories: deployment limits, launcher limits, and inventory limits. Deployment limits state which cruise-missile-capable platforms can legally carry nuclear cruise missiles. Such limits are generally easy to verify, can detect large covert deployments, but cannot protect against breakout, in which one side overtly violates the
treaty by quickly deploying illegal cruise missiles. Launcher limits place ceilings on the number of cruise-missile-capable launchers that can be deployed on ships, submarines, or bombers. They too are easy to verify. They also prevent breakouts but restrict conventional cruise missiles as severely as nuclear ones. Inventory limits govern the number of treaty accountable items (for instance cruise missiles) each side is allowed to produce, store, and deploy. These limits can be very costly to verify, but they do prevent breakout. In certain instances, they also leave conventional cruise missiles unfettered while still restricting the nuclear variants.

This study presents the argument that in START, a combination of deployment limits and simple inventory limits (those not attempting to detect covert production and storage) is the best means of controlling SLCMs. Specifically, deploying nuclear cruise missiles on surface ships or in submarine vertical launch tubes (VLS) should be prohibited. Conventional cruise missiles would be allowed in these launchers. These provisions would be verified by inspectors examining the contents of the cruise missile launch tubes while the vessels are in port. Going beyond these provisions would require strict limits on cruise missile inventories or on the number of allowed cruise missile launchers. The greater verification and operational penalties of such schemes are not worth the benefits they provide.

For ALCMs, launcher limits are useful in conjunction with deployment limits and simple inventory limits. In the current START framework, bombers carrying nuclear cruise missiles count toward the treaty ceilings on nuclear warheads and delivery vehicles. In addition, a class of dedicated conventional bombers should be excluded from the START counting rules on nuclear armed bombers. Deploying nuclear cruise missiles, or any other nuclear weapon, on such bombers would be prohibited. A ceiling on the number of dedicated conventional bombers (a launcher limit) would restrict the size of a potential breakout.

If the United States and Soviet Union continue to pursue strategic arms control to ceilings below those in START, strict inventory limits will become a more important option. Such limits appear to be viable only if a ban or low ceiling on all cruise missiles, nuclear and conventional, is enforced. The inspections required for verification are likely to be far more intrusive than those required to verify inventories of other treaty accountable items, such as mobile ballistic missiles. They may in fact be so intrusive that it would be simpler to limit inventories of nuclear warheads and material instead.
II. GOALS AND OPTIONS

U.S. GOALS IN CRUISE MISSILE ARMS CONTROL

Cruise missile arms control is included in the START debate at the insistence of the Soviets. The American interest in these negotiations is primarily to reduce the Soviet arsenal of heavy land-based ballistic missiles. The United States sees these weapons as a threat to crisis stability because of their potential capabilities against U.S. land-based ballistic missiles. The Soviets are willing to make substantial cuts in their arsenal of these heavy missiles, but one price they demand is limits on U.S. nuclear cruise missiles, both air and seabased.¹

The main U.S. goal in regard to START provisions on cruise missile arms control can thus be described as damage limitation. The United States needs provisions that satisfy the Soviets but do minimal damage to U.S. interests. Primarily, the United States would like to protect its ability to deploy large numbers of conventional cruise missiles on its bombers and naval vessels, avoid operational restrictions on its military forces, limit the costs of the required verification procedures, and sign a verifiable agreement. Soviet nuclear cruise missiles are not generally seen as a serious problem for the United States with an exception noted below. Controlling the Soviet nuclear cruise missile threat is therefore not a major U.S. goal in START.

The U.S. interest in long-range, conventional, land-attack cruise missiles stems from security concerns outside the purview of START. The most likely use of these weapons today is in selective attacks on high-value fixed assets such as command posts, air defenses, or special manufacturing facilities.² Currently, the primary U.S. means for conducting such missions are sea- and ground-based tactical aircraft. However, the ability to employ these assets is limited by

¹In his recent meeting with Secretary of State James Baker, Soviet Foreign Minister Edward Shevardnadze proposed that limits on SLCMs need not be part of the START treaty itself but could be handled in a side agreement. Washington Post, September 24, 1989, p.35.
²An example of such a target is the suspected Libyan chemical weapons plant. The United States considered attacking this plant with conventionally armed Tomahawk cruise missiles.
uncertain access to foreign bases, a limited supply of aircraft carriers, the proliferation of effective air defenses worldwide, and a growing taboo on collateral damage. Long-range conventional cruise missiles address each of these problems through their accuracy, small size, and expendability, and the diversity of platforms from which they can be launched. If the United States and its allies ever did find themselves in a war with the Soviet Union, the conventional cruise missile could be an important part of their conventional defense, with its ability to strike targets deep behind Soviet lines, penetrate Soviet air defenses, and enhance the survival of U.S. platforms by allowing them to stand further back and by dispersing the offensive role among more platforms. As guidance accuracies improve and more effective munitions are deployed, conventional SLCMs and ALCMs may provide very effective capabilities for performing a wide range of important missions.

While Soviet nuclear cruise missiles might pose many threats to the United States, only one is unique in the sense that other types of Soviet nuclear weapons cannot perform as well or better. This threat is the leading edge attack by SLCMs, probably from submarines. As commonly envisioned, a leading edge attack would involve a small number of nuclear SLCMs launched against key assets such as the national command authorities, command and control nodes, and alert bomber and tanker bases. A large follow-on attack of ballistic missiles would be timed to begin with the detonation of the cruise missile warheads at their targets. The concept is that the cruise missiles will disrupt the victim's ability to respond in the ten to twenty minutes of time between the ballistic missiles’ launch and impact. The uniqueness of SLCMs for this role is predicated on the possibility that they, unlike ballistic missiles or bombers, can arrive at their targets without warning.

There is considerable debate as to whether the leading edge threat is credible. If it does exist, it is likely to be from only a few tens of nuclear SLCMs because the number of vital targets is small; and the operational difficulties and the risk of detection increase with the number of cruise missiles in the attack. To remove this threat with

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3 See Froome, 1987, for a discussion of the importance of conventional SLCMs to the U.S. Navy. For a discussion of the potential roles of conventional ALCMs, see Hooper and Kent, 1987.

4 The Soviets claimed that their SLCM deployments in 1984 were meant to pose just such a threat to the United States, in response to the threat the Soviets perceived the Pershing II missiles in Europe posed to them. See Gottsche, 1987/88. For a discussion of some of the difficulties in conducting such an attack, see Postel, 1988/89.
arms control would require a ban or a near zero limit on nuclear cruise missiles. Verifying such low limits is difficult, and removing a leading edge threat would be a severe task for arms control. Fortunately, there are other options, such as improving the capabilities of the tactical warning and assessment systems and the survivability of the command and control net and retaliatory forces.

In the other missions that Soviet nuclear cruise missiles might conduct against the United States—such as being part of a major strike, a limited nuclear option, or the Soviets’ secure reserve—these weapons are one option among many the Soviets might employ. Because of their long flight times and the likelihood that a large attack of several hundred or more would be detected, the nuclear cruise missile is an undesirable weapon for a preemptive attack in any role other than the leading edge strike. The survivability of many cruise missile platforms helps reduce “use them or lose them” incentives to preempt with these weapons. In fact, cruise missiles are among the more benign places (relatively speaking) where the Soviet Union can put its nuclear weapons. The main U.S. arms control interest in Soviet nuclear cruise missiles is thus simple parity of numbers. They should not have more than we do.

In any arms control regime that limits nuclear cruise missiles and allows conventional ones there will be a problem with breakout, which is a natural consequence of the multipurpose character of the cruise missile. There is always a possibility that conventional cruise missiles can be converted to nuclear cruise missiles and that conventional cruise missile platforms can be armed with nuclear cruise missiles. Much of this report will deal with these issues. In fact, this problem is so pervasive that it is useful to identify two separate goals of the treaty. The first is to prevent covert deployments—that is, prevent Soviet nuclear cruise missiles in excess of those allowed by the treaty to be operationally deployed on bombers, ships, and submarines without the knowledge of the United States. The second goal is to prevent breakout—that is, deny the Soviets the capability of deploying excess nuclear cruise missiles a short time (less than a few weeks or months) after overtly violating one or more the treaty’s provisions. An example of such a violation would be denying a U.S. inspection team access to a Soviet facility the treaty allowed them to see.

Ironically, Soviet conventional cruise missiles may be a much more serious worry for the United States, since much of its military infrastructure is concentrated on long coasts with no air defenses.
In summary, the U.S. interest in controlling cruise missiles within START is primarily to obtain cuts in Soviet ballistic missiles and secondarily to prevent the Soviets from gaining an advantage by deploying more nuclear cruise missiles than the United States. From the U.S. point of view, cruise missile arms control is mainly an exercise in limiting damage. A satisfactory agreement should:

- Allow substantial deployments of U.S. conventional cruise missiles (up to several thousands on bombers, ships, and submarines);

- Be verifiable, with a verification regime that is miserly in its required costs. Costs include intelligence information lost, disruption of military operations, disruption of U.S. industrial facilities, and associated monetary expenses; and

- Avoid limitations on the number of allowed cruise-missile-capable platforms (ships, submarines, and bombers) since they can be used for tasks other than carrying nuclear cruise missiles.

Because the agreement would limit U.S. deployments of nuclear cruise missiles, it must also:

- Prevent large covert deployments (a few hundred or more) of Soviet nuclear cruise missiles; and

- Prevent a large Soviet breakout (a few hundred or more) of nuclear cruise missiles.

Finally, the agreement would remove a unique potential threat to the United States if it were able to:

- Prevent small covert deployments (a few tens) of Soviet nuclear cruise missiles.

This last goal is likely to be out of reach to any but the most restrictive treaty regimes.

One set of criteria notably lacking from this list is any that protects U.S. nuclear cruise missile options. Nuclear ALCMs are important to the United States, since they augment the bomber leg of the triad. An addendum to the above criteria is that the treaty should allow
adequate numbers of nuclear ALCMs to be deployed. Under the current START framework, the United States could deploy several thousand nuclear ALCMs without unbalancing its traditional triad of strategic nuclear forces. In contrast, nuclear SLCMs are less important for the United States to protect. As was the case for the Soviets, there are few unique missions for U.S. nuclear SLCMs. These weapons might be useful as an intermediate range nuclear force in Europe now that the Pershing IIs and ground-launched cruise missiles have been removed by the INF treaty, and some argue that the presence of nuclear SLCMs aboard U.S. ships is important to deter attack against these ships by nuclear weapons borne on long-range, land-based aircraft. To the extent these missions are important (in my view the first has more merit than the second), there are alternative U.S. nuclear weapons that can perform these roles. Submarine-launched nuclear missiles do have a role as a hedge, as an airbreathing weapon more survivable than those carried by land-based bombers. However, this role is amply protected by treaty provisions allowing several hundred nuclear SLCMs on submarines. This report therefore evaluates limits on nuclear SLCMs in terms of their verification costs and their restrictions on U.S. conventional forces, not in terms of the options forgone.

CRUISE MISSILE ARMS CONTROL OPTIONS

It is not possible for a cruise missile arms control agreement to fully satisfy all the above criteria. Any agreement must sacrifice one or more of these points. It is not surprising that the current U.S. position on controlling nuclear SLCMs in START is declaratory limits. (The United States has agreed to more comprehensive proposals for nuclear ALCMs.) The United States proposed to sign a letter along with the START treaty declaring U.S. plans for procuring and perhaps deploying nuclear SLCMs. The United States would promise to abide by these declarations, but there would be no verification provisions to allow the Soviets to confirm U.S. compliance. Such a solution is desirable from the U.S. point of view because it imposes no limits on any U.S. cruise missile deployments (nuclear or conventional) nor does it impose any verification costs. Although it also does nothing to contain any Soviet nuclear cruise

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7 Brooks, 1988/89.
missile deployments, its main drawback is that the Soviets have not agreed to it.8

This report explores other options for controlling nuclear cruise missiles. Those that might conceivably be applied are usefully collected under three distinct and general headings: deployment limits, launcher limits, and inventory limits. These options are listed in Table 1 and assessed against the criteria for desirable treaty provisions discussed above. None of these options satisfies all the criteria. The provisions of any actual treaty would probably encompass features of two or more options and would represent a compromise among, rather than full satisfaction of, all the criteria.

Deployment limits are treaty provisions governing on what platforms nuclear cruise missiles can legally be deployed, how many can be deployed there, or where such platforms are allowed to go. A typical example would be a rule stating no nuclear cruise missiles could be deployed on surface ships. As will be shown later, deployment limits can be constructed so that they are not costly to verify and allow large deployments of U.S. conventional cruise missiles. They can also successfully prevent large covert deployments of Soviet nuclear cruise missiles. However, because they do nothing to limit the capability of any platform to carry nuclear cruise missiles, they cannot prevent a large Soviet cruise missile breakout.

Launcher limits are treaty provisions governing the number of cruise-missile-capable launchers that can be legally deployed. Such limits can make no differentiation between nuclear and conventional cruise missiles. This option is similar to the classic arms control technique in which ballistic missiles and bombers are limited instead of nuclear warheads. An example would be banning cruise-missile-capable launch tubes on surface ships, or limiting the number of cruise-missile-capable bombers. Launcher limits are generally easy to verify since they rely largely on national technical means. They can prevent a Soviet breakout since it takes many months to years to build large numbers of cruise missile launchers. They would, however, restrict conventional cruise missile deployments and possibly the number of allowed bombers, ships, or submarines.

Inventory limits are treaty provisions that govern the number of weapons each side is allowed to possess, rather than merely deploy.

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8 The United States formally modified its position at the 1987 Washington Summit when President Reagan signed the Summit's Joint Communiqué binding both parties to seek "a mutually acceptable solution to the question of limiting the deployment of long-range nuclear-armed, sea-launched cruise missiles . . . and to seek mutually acceptable and effective means of verification."
<table>
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<tr>
<th>Limits</th>
<th>Cost of Verification</th>
<th>Allows Unrestricted Platforms</th>
<th>Allows Unrestricted Conventional Cruise Missiles</th>
<th>Limits Small Covert Deployments</th>
<th>Limits Large Covert Deployments</th>
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<td>Inventory Limits, Nuclear Cruise Missiles</td>
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<td>Inventory Limits, All Cruise Missiles</td>
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<tr>
<td>Inventory Limits, Nuclear Warheads and Materials</td>
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They can usefully concentrate on three types of items: nuclear cruise missiles, all cruise missiles, or nuclear warheads and materials. Depending on what is limited, inventory controls offer the potential of restricting large Soviet covert deployments, breakouts, and perhaps even small covert deployments. In some instances, they avoid restrictions on U.S. conventional cruise missile capabilities. However, inventory controls have as a general feature costly and complex verification schemes requiring the full array of verification tools—national technical means, data exchanges, perimeter portal monitoring of production facilities, challenge inspections of declared and suspect sites, and tagging of treaty-controlled items.9

The rest of this paper will discuss these options in more depth, justify the assessments presented in Table 1, and argue which combinations are the most appropriate for controlling nuclear ALCMs and SLCMs within START.

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9 These tools are discussed in several documents, as well as in Sec. V below. See for instance, Harvey and Ride, 1988.
III. DISTINGUISHING LONG-RANGE CRUISE MISSILES

It is important to make clear what types of cruise missiles must be controlled. Those relevant to START can carry a nuclear warhead against land targets over long ranges. In addition to the missiles explicitly configured for this role, there are systems that cannot be easily distinguished from nuclear, long-range, land-attack cruise missiles and systems that can be easily converted to such nuclear-armed missiles.

In general, a cruise missile is an unmanned, autonomous aircraft, generally small. It can carry a nuclear or conventional warhead against distant targets. There are many different types with many different characteristics. A cruise missile can have short range (a few tens of kilometers) or long (a thousand kilometers or more). It can attack land targets or ships at sea. It can be powered by a jet or rocket engine, although to be a cruise missile, it must rely on aerodynamic lift for most of its flight.

The most common role for cruise missiles is to attack ships. The Soviets have deployed several thousand anti-ship missiles, both conventionally and nuclear-armed, on their ships, submarines, and bombers. The vast majority of these missiles range between 50 km and 550 km; and many are old, large, rocket-powered systems. The United States has several hundred of the small, conventionally armed Harpoon cruise missiles, with a range of about 100 km, which are also deployed on ships, submarines, and bombers. Several other nations also field anti-ship cruise missiles, the most famous being the French Exocet, used by the Argentinians against the British and by the Iraqis against the American frigate USS Stark. Cruise missiles also play an important role for the United States and Soviet Union in short- and intermediate-range land-attack missions. Important U.S. examples include the SRAM, an air-launched, nuclear missile with a range of less than 200 km, and the SLAM, a variant of the Harpoon.

Despite its outward similarity to many of these systems, the modern long-range land-attack cruise missile is a unique weapon.\textsuperscript{1} Its effectiveness relies on two key technologies. Small, highly efficient turbofan jet engines are necessary for a missile of manageable size.

\footnote{1For a discussion of long-range land-attack cruise missiles, see Betts, 1981; Tselis, 1977.}
(on the order of 1000 kg) to carry a useful payload (a few hundred kilograms) a thousand kilometers or more. A highly accurate, range-independent guidance system is necessary for the missiles to make use of these ranges. Accuracies on the order of a few hundred feet are necessary if the cruise missile carries a nuclear weapon. A few tens of feet is required if the weapon is conventionally armed.

The United States has currently deployed two basic types of cruise missiles capable of nuclear, long-range, land attack: the AGM-86B, commonly referred to as ALCM and the BGM-109 Tomahawk. Both are subsonic vehicles designed to penetrate enemy air defenses with low observability (mainly because of their small size) and by flying low to the ground. The AGM-86B is nuclear-armed, deployed on B-52 bombers, weighs about 1200 kg, and has a range of approximately 2500 km under normal operating conditions. The Tomahawk also weighs about 1200 kg, has both conventional and nuclear-armed versions, and is deployed on surface ships and attack submarines. The nuclear version, the TLAM-N, has a range of about 2500 km. The conventionally armed version, the TLAM-C, has a range of roughly 1250 km, half that of the nuclear version because the conventional warhead is larger than the nuclear one and displaces space for storing fuel. There is also a conventionally armed anti-ship version of the Tomahawk, the TASM, which has an operational range of 450 km. This limit is not due to the physical capabilities of the

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2Ballistic missiles have always relied on inertial navigation systems (e.g. gyroscopes). These guidance sets lose accuracy at a constant rate as a function of time. However, the flight time of ballistic missiles over even intercontinental distances is short enough that inertial systems are sufficient. Cruise missiles take much longer to reach their targets and thus require some additional means of navigation. The terrain contour matching (TERCOM) navigation system provided sufficient accuracy for the American nuclear-armed cruise missiles first deployed in the early 1980s. With this system the cruise missile determines its location by periodically using radar to measure the contour of the terrain it is transiting. By comparing these measurements with contour maps stored in its guidance software, the missile can determine its location to within a few hundred feet. The digital scene matching area correlator (DSMAC) terminal guidance system works similarly to the TERCOM but uses a more precise optical sensor. It provided the additional accuracy required for the conventionally armed cruise missiles the United States began to deploy in the mid-1980s.

3I will not use this acronym to refer to the AGM-86B since I use it to refer more generally to all types of air-launched cruise missiles.

4The acronym is for Tomahawk Land-Attack Missile—Nuclear.

5This is the range when ship-launched. When submarine-launched the range is less because the missile cannot be propelled through the water with a full load of fuel.

6The acronym is for Tomahawk Anti-Ship Missile. This system should not be confused with the missile with an identical acronym, the Tactical Air-to-Surface Missile planned for NATO.
the missile's propulsion and airframe; the missile is programmed to fly no further because the Navy cannot in general identify ships at greater than this range. The United States is also planning to deploy at least two other types of cruise missiles capable of long-range land-attack missions. The ACM is a nuclear, air-launched system currently under development. The LRCCM is a conventional sea- and air-launched weapon currently under concept formulation by both the U.S. Navy and Air Force.

The Soviet Union has deployed one type of cruise missile capable of nuclear long-range land-attack missions. This system has both air- and sea-launched versions designated, respectively, AS-15 and SS-N-21 by Western intelligence sources. Both versions are similar to the U.S. Tomahawk, being subsonic, low-altitude missiles of approximately the same size, weight, and range. The Soviets also are developing the SS-NX-24, a high-altitude supersonic missile, which, in contrast to the U.S. cruise missiles and the AS-15/SS-N-21, is designed to outrun and overfly air defenses, rather than evading them by stealth. The AS-15 has been deployed on Bear H strategic bombers since 1984 and may in the future be deployed on BLACKJACK bombers. The SS-N-21 is just entering operational service. Although it is small enough to launch from the standard torpedo tubes on most Soviet vessels, it is likely to be deployed primarily on the newer classes of Soviet attack submarines. The SS- NX-24 has a sea-launched variant that may be ready for deployment in the early 1990s. To the best knowledge of Western sources, these Soviet missiles are only nuclear armed, with no conventionally armed variants.

Cruise missiles capable of nuclear long-range land-attack missions can be distinguished from the many cruise missiles not capable of such missions by their size, weight, and propulsion type. By distinguished, I mean that an observer at a distance can determine the capabilities of the missile. (In practice, a remote observer would estimate a missile's weight from its size.) Figure 1 plots the range

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Advanced Cruise Missile.

Long-Range Conventional Cruise Missile.

This information on Soviet cruise missiles is largely drawn from Gottemoeller, 1987/88.

Data from Jane's Missiles and Weapons 1987-89, 1988; and Cochran, Arkin, and Hoenig, 1984. The missiles included on this chart, with approximate weight and range values, are turbojet: ACM-86B (1458 kg, 2400 km); TLAM-N (1250 kg, 2500 km); TLAM-C (1250 kg, 1250 km); AS-15 (1700 kg, 3000 km); SS-N-21 (1700 kg, 3000 km); Tacit Rainbow (600 kg, 600 km). Turbofan: Harpoon (520 kg, 90 km). Rocket/ramjet:
of many types of U.S. and Soviet cruise missiles as a function of their weight and propulsion type. The figure includes nuclear- and conventionally armed missiles carrying payloads of different weights. The long-range cruise missiles all use high-efficiency, high-cost turbofan jet engines. Shorter-range cruise missiles are often smaller, and in all cases use less expensive turbojet engines or other types of propulsion, particularly rocket and ramjet engines. These latter two types are low cost and can provide supersonic speeds but are fuel inefficient and not suitable for long ranges. Several short-range,

RBS-15 (800 kg, 70 km); Otomat (700 kg, 160 km); AS-7 (300 kg, 8 km); AS-9 (750 kg, 75 km); AS-10 (300 kg, 25 km); AS-11 (300 kg, 25 km); AS-12 (350 kg, 35 km); AS-14 (300 kg, 30 km); SRAM (1020 kg, 200 km); Exocet (735 kg, 42 km). Missiles not in the figure because their weights are over 2000 kg or because their ranges or weights are unknown include turbojet: AS-2 (4200 kg, 120 km); AS-3 (11,000 kg, 650 km); SS-N-3 (10,000 kg, 450 km); SS-N-12 (550 km); SS-N-19 (<450 km). Rocket/ramjet: AS-4 (5900 kg, 400 km); AS-5 (3000 kg, 180 km); AS-6 (6000 kg, 400 km); SS-N-2 (2300 kg, 40 km); SS-N-7 (3375 kg, 64 km); SS-N-9 (2980 kg, 110 km); and SS-N-22 (110 km).
rocket-powered missiles weighing in excess of 2000 kg do not appear on Fig. 1.

The first point to be gleaned from Fig. 1 is that any cruise missile capable of carrying a large conventional warhead to long range can carry a nuclear warhead even further. This can be seen by noting that the TLAM-N and TLAM-C points represent systems with identical airframes and propulsion. There is no way to distinguish between a cruise missile capable of a conventional long-range, land-attack mission and one capable of a nuclear long-range, land-attack mission because, in fact, any missile capable of the first mission is capable of the second.

An observer with access to a cruise missile and proper equipment (radiation detectors, x-ray machines, or the like) can easily determine whether a particular long-range missile is at that moment conventional or nuclear armed. The missile can be tagged and sealed in its canister, so that a future observer with much simpler equipment can determine whether the warhead has been changed. However, it is not possible for an observer, even by close inspection, to guarantee that a conventional long-range cruise missile cannot be converted to a nuclear armed weapon. In a proper maintenance facility, it would take only a few days to weeks to disassemble any conventional cruise missile and insert a new warhead bay, if the necessary components had been previously manufactured and stockpiled.

It is important to understand what this fact does and does not entail. It is difficult, if not impossible, to convert a conventional SLCM to a nuclear one on board a ship. The Tomahawk, for instance, is environmentally sealed in its canister at a maintenance facility. The missile is built in sections, but to reassemble the sections requires careful alignments and numerous electrical connections. Furthermore, the Tomahawk is among the heaviest weapons in a ship's armament, and is not easy to move once it is on board. It is probably possible for a treaty regime to constrain the design of conventional cruise missiles in such a way that an inspector could examine it and certify that the missile's conventional warhead could not be changed anywhere but a well-equipped maintenance facility. For instance, an agreement might require the bodies of long-range conventional cruise missiles to be welded together so that the warhead could not be replaced without cutting the missile apart. However, in an onshore maintenance facility such a missile could be cut apart and given a nuclear warhead. The only way to prevent such
conversions is to identify and ban the facilities (and the necessary stockpiles of replacement parts).

The second point to be gleaned from Fig. 1 is that it is possible for a remote observer to distinguish cruise missiles capable of nuclear long-range, land-attack missions from cruise missiles not capable of such missions. For this to be possible, a long-range cruise missile must be defined as one whose range is on the order of 1000 km or more. A missile capable of carrying a reasonable size nuclear warhead to such ranges must weigh over 1000 kg if it has a turbojet engine, or over 750 kg if it has a turbofan engine. Any smaller missile, or any rocket-powered missile smaller than several thousand kg, will not be able to carry a nuclear warhead to long ranges. Because missile size and engine type are readily observable characteristics,\textsuperscript{11} it is possible, using roughly 1000 km to define long-range, to distinguish those missiles capable of carrying a nuclear warhead to long ranges from those that cannot.

\textsuperscript{11}Tsipis, 1977.
IV. CONTROLLING AIR-LAUNCHED CRUISE MISSILES

A framework for controlling nuclear ALCMs has been substantially agreed upon by the START negotiators, though some issues remain unresolved. In particular, it is unclear how severely the current treaty draft would restrict U.S. conventional ALCM deployments. This section will show that the existing framework is a combination of deployment and launcher limits schemes and will suggest a means for resolving the problems remaining in the plan.

The current START framework calls for ceilings on the arsenals of U.S. and Soviet strategic nuclear delivery vehicles (SNDVs) and on accountable strategic nuclear warheads.\(^1\) SNDVs include ballistic missiles and bombers and are limited to 1600 on each side. The number of accountable strategic nuclear warheads, limited to 6000 on each side, is determined by counting rules based on the number of different types of SNDVs.\(^2\) The purpose of the warhead ceilings is to prevent the proliferation of multiple warheads on individual delivery vehicles, which was one problem with the previous SALT accords. Nonetheless, the START treaty, in the tradition of these past agreements, would control strategic nuclear capability through limits on platforms rather than on weapons.

In the current START framework, a heavy bomber that carries no long-range cruise missiles counts one toward the SNDV ceiling and one toward the nuclear warhead ceiling, no matter how many nuclear weapons it actually carries. For instance, a B-1B bomber loaded with 20 nuclear gravity bombs would count as only one warhead.

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\(^{1}\)Information on the current START framework was largely taken from Einhorn, 1988.

\(^{2}\)The treaty framework includes the following main elements:

i. A ceiling of 1600 strategic offensive delivery vehicles on each side. Each ICBM, SLBM, and heavy bomber counts as one delivery vehicle,

ii. A ceiling of 6000 on warheads carried by the delivery vehicles. Warheads are attributed to delivery vehicles by counting rules,

iii. A subceiling of 4900 warheads on ballistic missiles,

iv. A subceiling of 154 heavy ballistic missiles and 1540 warheads carried by such missiles.
Agreement to this U.S.-proposed counting rule was a major Soviet concession at the Reykjavik Summit. Among the reasons the United States favors this rule, which counts bomber warheads less than ballistic missile warheads, is that bombers have to face air defenses that ballistic missiles do not, and because bombers are slow flying systems that do not pose a serious preemptive threat.

A heavy bomber carrying long-range nuclear-armed cruise missiles also counts as one toward the SNDV ceiling in the current treaty framework. The sides disagree, however, on the number such a bomber should count against the warhead ceiling. The Soviet position is that the number should be the maximum number of cruise missiles the bomber is equipped to carry, while the U.S. position is that the number should be ten warheads, since bombers rarely fly with their full complement of cruise missiles. The treaty would also allow each side to deploy dedicated conventional bombers that carry no nuclear weapons, but could carry conventional cruise missiles. The Soviets propose that each such bomber count as one SNDV. The United States proposes that they do not count at all against the treaty ceilings.

The two sides also disagree on the definition of a conventional cruise missile. Both agree that any class of long-range ALCM that has ever been tested or deployed with a nuclear variant will be considered to be a nuclear ALCM. They also agree that all future conventional long-range ALCMs be distinguishable from nuclear long-range ALCMs. Publicly, the Soviets’ position is that the distinguishing characteristics be functionally related observables. We have seen, however, that such functionally related observable differences are impossible. The Soviets further propose that any cruise missile with a range over 600 km be defined a nuclear long-range cruise missile, whether or not it is conventionally armed. The United States proposes that only a missile with a range greater than 1500 km be defined as long range and that only those types actually carrying nuclear warheads should be defined as nuclear long-range cruise missiles.

Although the class of dedicated conventional bombers is recognized in the current START framework, the differences in the U.S. and Soviet positions regarding what constitutes a conventional long-range cruise missile make it unclear whether the treaty as it now stands

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3The U.S. B-52G carries 12 cruise missiles, the B-52H will carry 20 cruise missiles, and the Soviet Bear H, eight cruise missiles.

would allow these bombers to carry long-range conventional ALCMs. If they are not, START would seriously restrict the U.S. ability to deploy a conventional ALCM force. The treaty framework is also unclear on how the treaty regime will prevent covert deployments of excess nuclear ALCMs, and how it will cope with the breakout problem.

The rest of this section will present what I believe is the best means of dealing with these problems. The approach is deliberately crafted to be as close as possible to the existing START framework on ALCMs.

The first step is to explicitly define three classes of heavy bombers:

1. **Nuclear penetrating bombers**, which are bombers equipped and employed to carry only short-range nuclear weapons. Examples include the Soviet Bear B/C/Gs and the U.S. B-1Bs.

2. **Nuclear standoff bombers**, which are nuclear-armed heavy bombers equipped and employed to carry large cruise missiles. Examples include the Soviet Bear Hs and U.S. B-52Hs carrying AGM-86B missiles.

3. **Dedicated conventional bombers**, which are heavy bombers dedicated to carrying conventional weapons only. There are no current examples of such aircraft, though the United States used B-52s as conventional penetrating bombers during the Vietnam war.  

The current counting rules on these bomber classes can then be summarized as in Table 2, where differing U.S. and Soviet positions are represented with two entries divided by a slash. These counting rules are an example of the strategy of launcher limits, because they restrict how many cruise-missile-capable bombers can be deployed. The problem of allowing conventional ALCMs on the dedicated conventional bombers is a question of deployment limits. How and to what extent should the treaty restrict the deployment of nuclear cruise missiles on certain cruise-missile-capable bombers?

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There are bomber variants on both sides dedicated to maritime missions. Examples include the U.S. B-52Gs armed with Harpoon missiles and the Soviet Bear D/E/F reconnaissance aircraft. It is not clear whether these aircraft should be considered dedicated conventional bombers under START or neglected all together.
Table 2

BOMBER CLASSES AND PROPOSED COUNTING RULES

<table>
<thead>
<tr>
<th>Bomber Class</th>
<th>Accountable Vehicles</th>
<th>Accountable Warheads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Penetrator</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nuclear Standoff</td>
<td>1</td>
<td>10/8–20</td>
</tr>
<tr>
<td>Conventional</td>
<td>0/1</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Entries divided by a slash represent differing U.S./Soviet proposals.

The U.S. and Soviet debate on what defines a conventional long-range cruise missile is a sidelight to this main issue. Any bomber physically capable of carrying a cruise missile weighing over 1000 kg can carry any long-range cruise missile, whether it is nuclear- or conventional-armed. There are no permanent physical differences between nuclear-capable and dedicated conventional bombers, so even if inspectors were allowed complete access to an aircraft, there would be no permanent indicators there to find. The avionics necessary to launch conventional long-range cruise missiles are no less capable than those needed for nuclear cruise missiles. Any equipment related solely to nuclear operations, such as the safe-and-arm systems, could be mounted in the wing pylons and internal launchers and removed from an inspected bomber along with the nuclear cruise missiles.  

Thus, the problem in allowing dedicated conventional bombers to carry long-range conventional cruise missiles is not how to make conventional and nuclear long-range cruise missiles distinguishable, but how to keep nuclear cruise missiles off the conventional bombers.  

One means of solving this problem is through a strategy of deployment limits that prohibits dedicated conventional bombers from carrying nuclear cruise missiles. Such provisions could be protected against covert infractions with a two-pronged approach.

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4Personal communications with engineers at the Boeing Corporation.
5It is easier to distinguish bombers capable of carrying heavy cruise missiles from those not so capable. There are several operational distinctions—bombers that are never tested or trained with large cruise missiles are not likely to be able to use them in time of war. If these are not seen as sufficient, there are also several physical distinctions that might be required by a treaty. Hard points on the wings of nuclear standoff bombers could be prohibited, and their bomb bays could be required to be partitioned into sections too small for a long-range cruise missile. Both of these features could be verified by inspectors given access to the bomber.
The treaty could require bombers in each of the three classes to be distinguishable when viewed by national technical means. On-site challenge inspections could ensure that individual bombers carry only the armaments allowed to their declared class. Launcher limits that place ceilings on the number of allowed dedicated conventional bombers could supplement the deployment limits to restrict the potential for a rapid, overt breakout.

The most straightforward way to make bombers in different classes distinguishable is to place all the members of a particular bomber type in a single class. A bomber type is all aircraft sharing the same designation—e.g. B-1B, B-52G. Alternatively, bombers of the same type in different classes could have observable differences. These differences could be either functionally related, for example cruise missile launch pylons visible beneath the wings—or not functionally related—for example nonstructural fairings on the wing of all cruise-missile-carrying bombers. Once the bombers of different classes are distinguishable, their numbers can be accurately estimated with national technical means.\(^8\)

Several measures can be taken to ensure bombers carry only the armaments they are allowed and in particular that dedicated conventional bombers are not covertly armed with nuclear ALCMs. First, the treaty can restrict these bombers to operate only from bases not used by nuclear-armed bombers. Inspectors could visit these bases and certify that they have no nuclear handling capability. More difficult is verifying the bombers stay away from bases at which they are not allowed. National technical means cannot monitor the location of all bombers at all times, particularly at night or on cloudy days. Most important, the treaty can authorize short notice, on-site challenge inspections of the dedicated conventional bombers at their bases to verify that at the time of the inspection the inspected bombers are not carrying nuclear weapons.\(^9\) The detection of one dedicated conventional bomber carrying a nuclear weapon would constitute a violation of the treaty. Thus, while the treaty's inspection regime remains in force, any large covert deployments of nuclear ALCMs on dedicated conventional bombers would probably be prevented.

These deployment limits provisions do little, however, to prevent a breakout in which dedicated conventional bombers are overtly loaded

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\(^8\)Wilkerson, 1985.

\(^9\)Since bombers can be moved quickly, the inspectors should be resident near the bases.
with nuclear ALCMs. In time of crisis or war, either side could quickly fly its dedicated conventional bombers to a base with prepositioned stocks of nuclear cruise missiles. These provisions might give some warning that a breakout is underway and increase the risks of conducting such operations since they complicate the training of the necessary ground and flight crews. However, these deployment limits cannot prevent the breakout itself.

One way to make a breakout more difficult is to impose inventory limits that place ceilings on the number of nuclear cruise missiles each side is allowed to possess. The goal is to restrict the number of nuclear missiles available for the dedicated conventional bombers. The verification required by such inventory limits would be on a different plane of difficulty than that envisioned for the current START provisions on ALCMs. In addition, any inventory limits on nuclear ALCMs would probably be undertaken in concert with inventory controls on nuclear SLCMs, since there is little physical difference between the two types of weapons. For these reasons, the discussion of inventory limits is deferred to the next section.

An alternative strategy is to limit the size of a potential breakout by limiting the number of allowed dedicated conventional bombers. This is an example of the launcher limits. For example, a treaty subceiling of 100 dedicated conventional bombers, separate from the treaty's ceilings on nuclear warheads and delivery vehicles, would permit most conventional missions\(^{10}\) and would cap the Soviet breakout potential at about 1000 cruise missile warheads. The idea is to exploit the fact that the nuclear cruise-missile-carrying capacity of a bomber fleet depends strongly on the number of available bombers. In contrast, the conventional cruise-missile-carrying capacity depends more strongly on the number of stockpiled cruise missiles, since in a typical campaign the bombers will make many sorties.

Limiting the number of dedicated conventional bombers is inconsistent with the current U.S. position that no conventional weapons be limited in START. However, the United States must weigh this desire against the risk of allowing the Soviets unrestricted dedicated conventional bombers that they might use for a breakout. The perceived risk may be large or small depending on whether the U.S. government concludes the Soviets are likely to build a large number of bombers. The Soviets' proposal to count each conventional

\(^{10}\)Hosner and Kent, 1987. The United States could deploy about 100 conventional bombers within its current bomber acquisition plans without the need to buy any additional aircraft.
bomber as one against the nuclear delivery vehicle ceiling is another possible counting rule to restrict breakout, particularly if such aircraft also counted as one against the warhead ceiling. However, this Soviet proposal may not be as desirable as a simple ceiling on dedicated conventional bombers.

What is the point of allowing separate treatment of conventional bombers when it is impossible to prevent these bombers from carrying nuclear cruise missiles? The primary reason, of course, is to allow the United States to more easily deploy bombers armed with conventional ALCMs. The separate treatment of the conventional and nuclear bombers can be justified by the operational constraints that make the former less useful for carrying nuclear weapons. Conventional bomber crews cannot easily train for nuclear missions; and the bombers are not available for a nuclear surprise attack because they cannot be loaded with nuclear weapons without breaking the treaty and providing warning of the impending hostilities. Prohibiting the conventional standoff bombers from legally carrying nuclear weapons or operating from known nuclear-capable bases provides some minimal operational constraints on employing these bombers as a nuclear force. However, separate treaty ceilings on dedicated conventional bombers are necessary to provide real restrictions on breakout. These ceilings enforce explicit tradeoffs between nuclear and conventional capabilities. Either side could augment their arsenal of nuclear cruise missiles, but only at the expense of their capability to carry out missions with conventional cruise missiles. The separate ceilings can be thought of as a weak nuclear counting rule on dedicated conventional bombers. Under this interpretation, the roomy ceilings for these bombers reflect the fact that they could be nuclear armed, but penalties and constraints diminish their utility as nuclear cruise missile carriers.
V. CONTROLLING SEA-LAUNCHED CRUISE MISSILES

In contrast to the situation for ALCMs, there is little agreement between the Soviet and American governments on how to treat sea-launched cruise missiles\(^1\) within START. The joint communiqué issued at the Washington summit in December 1987 pledged both sides to seek a mutually acceptable, verifiable means of limiting long-range nuclear SLCMs. Beyond this general commitment, the two sides remain far apart.

The Soviets have proposed a ceiling of 400 nuclear long-range SLCMs, and a ceiling of 600 conventional long-range SLCMs,\(^2\) but have expressed a willingness to accept an overall ceiling of 1000 on all long-range SLCMs with no separate limits on nuclear and conventional variants.\(^3\) The Soviets propose to verify these ceilings with continuous monitoring of arming and loading stations, and inspection of ships. The United States does not accept these Soviet positions, in large part, because it does not believe the Soviet verification scheme is viable. The U.S. government's position remains that at present there is no scheme that can be adequately monitored. Despite the joint communiqué, the United States has no official position beyond non-binding declarations of SLCM production and deployment plans.

Constructing verifiable SLCM controls is difficult, in part because of the problems associated with inspecting ships and submarines, and because these vessels fill multiple roles. Surface ships are sufficiently large that highly intrusive inspections would be required to thoroughly search them for the small SLCMs. The U.S. Navy is likely to strongly oppose internal inspection of submarines because of the important design information such inspections might reveal. In addition, it is very difficult to restrict the SLCM-carrying capability of surface ships and submarines without substantially compromising many other missions. The naval launchers that carry torpedoes, anti-ship missiles, and anti-submarine rockets are often compatible with long-range land-attack cruise missiles as well. Ships and submarines

\(^1\)By SLCMs, I mean cruise missiles capable of long-range land-attack missions, both nuclear and conventional. I do not include the short-range anti-ship missiles.


\(^3\)The current U.S. deployment plans call for approximately 750 nuclear and 2600 conventional long-range land-attack SLCMs.
often operate independently of their bases for long periods and may leave port uncertain of what missions they will be called upon to perform. Carrying a variety of weapons in multipurpose launchers is integral to the operation of modern naval vessels.

The Navy's policy to neither confirm nor deny the presence of nuclear weapons on board specific vessels is often portrayed as a major obstacle to SLCM arms control. Although this policy would preclude some types of SLCM limitations, it is by no means a serious impediment to limiting them. It would not be difficult to arrange a procedure that required both sides to declare all their SLCM production sites and all their facilities for placing nuclear warheads on SLCMs. All cruise missiles from such sites would be required to pass through a special verification facility before proceeding to their deployment or storage areas. At these facilities, any cruise missile declared to be conventional would be examined with radiation detectors or x-ray machines to determine that it was indeed not nuclear. (There would be no need to examine any missile declared to be nuclear, and thus no possibility of revealing sensitive nuclear warhead design information.) All the conventional and nuclear cruise missiles would then be counted, sealed in their canisters, and their canisters tagged. Once in the canister, the cruise missile's warhead could not be changed without breaking the seal. The tags and seals must be non-reproducible, identifiable, environmentally stable, and tamper proof. The requisite technologies are currently under development and should be available by the time the treaty is ready to sign.

Such a scheme would eliminate the need for inspectors to examine cruise missiles at naval bases or on naval vessels, to carry any type of nuclear detection equipment, or to determine whether a particular cruise missile is nuclear. Inspectors need only verify the presence of a legitimate tag and an unbroken seal on each missile. If the treaty bans nuclear SLCMs from certain types of vessels, the tags on individual SLCMs could be distinguishable. The inspector examines a list to determine whether a particular tag was placed on a nuclear or conventional SLCM. If both conventional and nuclear SLCMs are allowed on certain vessels, tags could be randomly placed on missiles at the special verification facility. The verification list would record

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4Missiles returning for maintenance from deployment or storage would pass back through the special verification facility and have their tags removed. Returning from maintenance, they would pass again through the facility to be recounted, retagged, and rescaled.
only the identity of legitimate tags. There would be no record of what type of missile the tags were on.

This section will present options for a viable SLCM control regime within START. Such a regime should rest primarily on deployment and launcher limits combined with simple schemes to monitor SLCM inventories such as the one described above. True inventory limits, those that enforce ceilings on the number of legally possessed SLCMs, notwithstanding any efforts to produce or store them covertly, have penalties too high to offset the benefits they provide within START. A natural spinoff of this discussion is suggestions on how SLCM controls might be handled in some future treaty whose ceilings on strategic warheads lie considerably below those currently envisioned.

DEPLOYMENT LIMITS

As applied to SLCMs, deployment limits are those provisions restricting which ships and submarines can legally carry conventional and nuclear SLCMs, how many cruise missiles these vessels can legally carry, and where these vessels can legally go. Many deployment limits schemes take on a different character for surface ships than for submarines because surface ships are less sensitive to inspections than submarines, and because the restricted volume inside a submarine constrains the number of weapons it can carry.

Two important deployment limits schemes for surface ships are a ban on nuclear SLCMs on surface ships and a ban on untagged SLCMs on surface ships. These two are simple variants of one another. The first scheme would prohibit nuclear SLCMs from being deployed on any surface ship but would allow unlimited deployments of conventional SLCMs on declared carriers. The second scheme would tag SLCMs as described above and place a ceiling on the number of tagged nuclear SLCMs. An unlimited number of conventional SLCMs could also be tagged. SLCMs would be allowed only on declared surface ships, and only if they were tagged.

The treaty would define any ship with SLCM-capable launch tubes as a declared SLCM carrier. These launch tubes would be subject to inspections while the vessels were in port to verify that they were not loaded with nuclear SLCMs or that all SLCMs were properly tagged. (In practice, the first scheme would be implemented by tagging all conventional SLCMs, so that inspectors need not carry radiation detectors on board ships.) Reloading SLCMs at sea or at foreign ports

\(^{5}\)Table 3 below summarizes the options discussed here.
would be prohibited. For reasons discussed below, this scheme is most desirable if deployments of nuclear SLCMs are legally allowed on submarines.

The advantages of using one of these two schemes to limit the number of deployed nuclear SLCMs include a simple verification regime, minimal interference with naval operations, no compromise of sensitive intelligence information, and unlimited legal deployments of conventional SLCMs. The scheme's simplicity is owed to the requirement that inspectors need examine only the contents of SLCM launch tubes, which open onto the exterior of the ship. Such inspections are not likely to sacrifice any substantial intelligence information, nor compromise the U.S. Navy's neither confirm nor deny policy.

The effectiveness of these bans on nuclear or untagged SLCMs is degraded if a substantial capability to reload SLCM launchers exists at sea, either from internal magazines, or from a tender. Reloading these launchers at sea is not easy. Long-range cruise missiles are the heaviest weapons carried by ships, and the equipment needed to move them is substantial and generally lacking from these vessels. The treaty might include provisions designed to make reloading SLCM tubes more difficult. It could explicitly ban reloads from tenders, relying on national technical means and other forms of reconnaissance to detect pervasive, large-scale infractions. To restrict reloads from onboard magazines, inspectors could be charged with determining that the region around SLCM launch tubes was free of the heavy lifting equipment necessary to move the SLCMs. Alternatively, if one or both navies were unwilling to sacrifice the ability to reload their conventional SLCM tubes at sea, the verification regime could be made more intrusive to determine that none of the potential sources of reloads contained stocks of nuclear or untagged SLCMs. For instance, inspectors could be given access to any magazine on a ship for which the heavy lifting equipment existed to reload SLCM launchers. Any tenders capable of reloading SLCMs at sea would be required to be made available for intrusive inspections of any storage areas accessible to the SLCM reloading equipment.

These bans on nuclear and untagged SLCM would be incapable of preventing small violations in the form of reloads from covert tenders or magazines or illegal SLCMs hidden in covert launchers, either on

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6This last provision is helpful because the host nations would not be partners to the START treaty and not bound to let inspectors onto their naval bases.
declared SLCM carriers or on ships declared not to carry SLCMs. In this latter category could be warships (aircraft carriers, for example) or supposed noncombatants such as trawlers. It would be fairly easy to covertly deploy small numbers of illegal SLCMs in these ways. However, larger deployments, on the order of a few hundred SLCMs or more, would run a large risk of being detected. For this reason, it is important that a ban on nuclear or untagged SLCMs on ships be complemented with provisions allowing nuclear SLCMs on submarines. Submarines are more useful platforms for nuclear SLCMs because they are more survivable. If nuclear SLCMs are legal on submarines, then illegal nuclear SLCMs on surface ships would only provide additional military utility when their numbers are large. The inspection scheme outlined here can make it difficult for illegal large deployments to be covert.

A ban on nuclear or untagged SLCMs also cannot prevent a breakout. The treaty provisions do nothing to prevent a conventional SLCM-capable ship from being overtly loaded with nuclear SLCMs. Such a ship would not be useful in a war beginning with a surprise attack, or developing quickly from a crisis, because it would be days or weeks of sailing from its launch area at the time it acquired its nuclear SLCM load. However, several weeks after a severe crisis or war brought the treaty-mandated inspections to an end, surface ships armed with nuclear SLCMs could be at their stations. From the U.S. point of view, the importance of this threat is limited because the Soviets would gain only marginal military utility from these nuclear SLCMs to that provided by their legal deployments on submarines and by their arsenals of ballistic missiles. The U.S. Navy has considerable ability to keep Soviet ships away from likely SLCM launch points after several weeks of severe crisis or war. Nonetheless, accepting this breakout potential is an unavoidable consequence of this schemes' allowance of an unlimited capability to launch conventional SLCMs. Restricting the breakout potential requires substantial limitations on conventional SLCM launch capabilities, conventional SLCM inventories, or inventories of nuclear warheads themselves. As discussed below, each of these options would impose severe costs on the United States. A Soviet SLCM breakout by the Soviet surface fleet does not appear to be a substantial enough threat to justify imposing these measures.

For submarines, a similar ban on nuclear or untagged SLCMs can not be verified by inspecting the contents of SLCM-capable launchers. The main problem is that torpedo tubes are reloadable. To examine the contents of the torpedo room, inspectors must be given internal
access to the submarine. These inspections risk revealing sensitive information on submarine designs. The risk is sufficiently high to remove this as a reasonable way to enforce a deployment limits scheme. Another difference between submarines and surface ships is that verifying a particular submarine is not a SLCM carrier is a more difficult task than verifying the same for ships. Most torpedo tubes are SLCM-capable launchers, so most submarines must be regarded as SLCM-capable. Although there are indicators that certain types of submarines do not carry SLCMs (for instance the lack of test launches and patrols in possible launch areas), these indicators are more ambiguous than the simple absence of SLCM-capable launch tubes.

Despite these problems, the small volume available on submarines for weapon storage can ease the problem of controlling SLCMs on these vessels. U.S. Los Angeles-class submarines can carry 26 weapons for their torpedo tubes. However, this total includes all the torpedoes, Harpoon anti-ship missiles, and conventional and nuclear SLCMs. The estimated number of weapons carried for torpedo tubes by Soviet submarines is slightly less. Normally a Los Angeles-class submarine will carry only four SLCMs, conventional and nuclear. If carrying more, the submarine's ability to conduct other missions, including self-defense, is greatly reduced. Some U.S. submarines also have eight VLS tubes, which can be devoted to SLCMs. Although these tubes can increase the submarine's SLCM capacity, they are also readily observable and can be subject to additional arms control constraints as described below.

One arms control option for submarine-launched SLCMs is simply to ignore any that might be carried for launch from torpedo tubes. Each side has about 100 attack submarines suitable for SLCM missions. The total number of nuclear SLCMs available on these submarines is on the order of 400, and certainly no more than a thousand. Banning nuclear SLCMs on surface ships, while limiting VLS-launched SLCMs and ignoring torpedo-tube-launched SLCMs, might offer a tolerable and effective ceiling on the number of nuclear SLCMs carried by each side.

SLCMs in VLS tubes could be treated similarly to those on surface ships (that is, with a ban on nuclear SLCMs in these tubes). A ban on nuclear SLCMs, as opposed to untagged SLCMs, makes more sense in

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8Jane's Fighting Ships, 1988-89.
this context because it provides lower overall ceilings on the numbers of deployed nuclear SLCMs. The enforcement would be the same as that for ships, with inspectors examining the contents of the VLS tubes in port.

Another option would be to allow SLCMs only on declared types of submarines. Any submarine with VLS tubes would be a declared SLCM carrier. As mentioned above, it would be difficult to verify that an undeclared submarine did not carry SLCMs. However, the limited SLCM capacity of individual submarines and the absence of operational indicators of SLCM activity might well be considered sufficient verification.

A final, though more complex, option is to ban the deployment of untagged SLCMs on submarines and enforce this ban by monitoring the weapons taken on and off these vessels in port. The benefits and drawbacks of such a scheme are similar to those for surface ships. However, the inspection scheme is slightly more difficult because inspectors must be present during the loading and unloading of weapons. They must also be reasonably assured that any illegal weapons are not just kept on board the vessel and unloaded once the inspectors leave.

Two other examples of the deployment limits option are keepout zones and a ban on all naval nuclear weapons (except ballistic missiles). Neither is as useful for controlling nuclear SLCMs as those just discussed. Keepout zones are areas in which the treaty would prohibit SLCM-carrying vessels from entering. The main advantage of such zones, other than their negotiability (the Soviets have been favoring them for years), is that they make conducting a leading edge attack more risky. Because all nuclear SLCM carriers would probably be banned from waters within cruise missile range of important targets in the United States and Soviet Union, any such vessel preparing to launch a leading edge attack might compromise the attack if detected.

However, keepout zones cannot reliably provide such warning. Detecting any recurring small-scale incursions would be very difficult because the intruders could be modern, quiet submarines or trawlers covertly carrying SLCMs. Such incursions would considerably degrade the benefit keepout zones are intended to provide. In addition, keepout zones would place serious operational constraints on the U.S. Navy. Zones drawn to prevent nuclear attacks on the Soviet Union might also restrict conventional SLCM attacks in many

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10 Such an option is discussed in Gottemoeller, 1988.
potential theaters not involving the Soviet Union, such as the Persian Gulf, Middle East, and South Korea. Peacetime intelligence gathering against the Soviet Union might also be eliminated. Most important, perhaps, keepout zones are in conflict with the longstanding U.S. commitment to unrestricted freedom of the seas.

A ban on all naval nuclear weapons except for SLBMs is often advocated as a goal in its own right.\textsuperscript{\ref{11}} Although assessing this argument is beyond the scope of this report, many commentators argue that adopting such a ban would simplify the control of nuclear SLCMs, because the detection of any nuclear weapon on board a naval vessel would be a violation of the treaty.

Detecting nuclear weapons on board ships or submarines is sufficiently difficult that banning all naval nuclear weapons except ballistic missiles does not solve the problem of detecting nuclear SLCMs. Early in 1988, General Secretary Gorbachev prompted a flurry of interest in remote radiation detectors for detecting the presence of naval nuclear warheads when he stated the Soviets had technologies that could perform this task.\textsuperscript{\ref{12}} It soon became clear that Gorbachev had misunderstood the capabilities his scientists had described to him. The Soviet scientists in question soon stated that although in principle shipboard nuclear weapons could be detected out to about 100m with existing sensors, such detection could be easily defeated by a moderate amount of shielding.\textsuperscript{\ref{13}} Shielding is simple to provide in submarines and even more so in surface ships. Thus, such detectors are useless as a verification tool.\textsuperscript{\ref{14}}

Without remote detectors, and without thorough inspections inside ships and submarines, a naval nuclear weapons ban would be verified by noting the lack of a nuclear handling infrastructure at ports and, to a lesser extent, by observing naval operations. Human intelligence, particularly reports from former or current Soviet sailors, would undoubtedly play an important role. A naval nuclear weapons ban would thus help, but not solve, the problem of controlling nuclear SLCMs.

\textsuperscript{\ref{11}}Among the proponents of a naval nuclear weapons ban are Nitze, 1988. Also see Daalder and Zimmerman, 1988.


\textsuperscript{\ref{13}}Sagdeev, Prlutatsik, and Frolov, 1988.

\textsuperscript{\ref{14}}Recently a team of U.S. observers measured the radiative emissions from a short-range nuclear anti-ship cruise missile onboard a Soviet cruiser, as reported in the Washington Post, July 6, 1988. The importance of this measurement was that the team was given access to the Soviet ship. The demonstration did not suggest a means to detect shipboard nuclear weapons if efforts are made to hide them.
LAUNCHER LIMITS

As applied to SLCMs, launcher limits restrict the total number of SLCM-capable launchers on the ships and submarines in a fleet. Unlike deployment limits, SLCM controls based on launcher limits can restrict the potential size of any breakout. However, this benefit comes at the expense of being unable to differentiate between nuclear and conventional SLCM capabilities. Thus, launcher limits are generally not useful for controlling SLCMs in START.

An exception is an overall limit on the number of submarine VLS tubes in each fleet. This option could be pursued instead of, or in addition to, a ban on deploying nuclear SLCMs in these tubes. The total number of VLS tubes could be limited with an exchange of data on the number of such tubes on each type of submarine and verified by national technical means and other forms of reconnaissance. Such a scheme could effectively limit the number of nuclear SLCMs that could be carried on a submarine fleet, even during a crisis or war that dissolved the treaty inspection regime.

Launcher limits are less helpful for limiting SLCM-capable launch tubes on surface ships because such limits would prevent these ships from being useful carriers of conventional SLCMs, as well as other heavy munitions. Assuming that it is desired to keep the number of potentially deployed nuclear SLCMs below 1000, and that 400 or more nuclear SLCMs can be carried on submarines, a launcher limit scheme would have to restrict each surface fleet to several hundred SLCM-capable launchers. The relevant launchers would be those capable of launching a missile weighing 750 kg or more. This scheme would require the Soviets to dismantle many of their launchers for their short-range anti-ship cruise missiles. The U.S. Navy would also sacrifice many of its launchers for heavy armaments, including many anti-ship and anti-submarine weapons. In particular, the Navy would be forced to place a few conventional SLCMs on many ships or many conventional SLCMs on a few ships. Either the flexibility or size of conventional SLCM operations would be compromised.

The U.S. government might decide these restrictions are tolerable, especially since many conventional SLCM missions can be performed by conventional ALCMs. A more likely scenario under START is that the United States will conclude these penalties do not outweigh the gains in ease of verification and protection against breakout. However, in a future strategic arms limitation treaty with ceilings considerably lower than in START's, the SLCM breakout threat may
become more important to contain. In such circumstances, this launcher limits scheme may be a more useful option.

INVENTORY LIMITS

Because of all the difficulties associated with employing more traditional arms control schemes to SLCMs, there has been great interest in applying inventory limits to these weapons. Such plans would set ceilings on the total number of SLCMs or the total number of nuclear SLCMs each side could legally produce and stockpile. Such schemes might avoid the need for direct inspection of ships and submarines and, if successful, would prevent breakout. The main drawback is that successfully monitoring the stockpiles and production of another country's SLCMs requires a great deal of cooperation and probably direct access by inspectors to storage depots and factories.

The interest in inventory controls has been fanned by the truly momentous political developments under way in the Soviet Union. Until recently, no onsite inspection regime was acceptable to the Soviets. Now, however, so many barriers are down it is not clear which ones remain. In addition to the numerous and unprecedented verification proposals for START and the newly convened talks on Conventional Forces in Europe, the 1987 Intermediate-range Nuclear Forces (INF) Treaty has already mandated a host of procedures that are already in place. Among them are a detailed data exchange on the characteristics and deployments of the missiles banned by the treaty, continuous monitoring by inspection teams of all exits to the factories that made the banned missiles (one factory on each side is subject to this monitoring), and inspections of bases where these missiles were formerly stored. These new, powerful tools hold great promise for several arms control problems, including the difficult one of SLCMs.

Amidst the flood of possibilities, it is important to separate out what inventory limits might easily accomplish, and what will remain truly difficult. The easy task is to place ceilings on those SLCMs produced and stored at sites known or declared to be involved in SLCM production and storage. The difficult task is to place strict ceilings on the total number of SLCMs, notwithstanding efforts to produce or store them covertly.

An inventory limits scheme that places ceilings on SLCMs produced and stored at known sites would have modest inspection requirements. The verification procedures would be similar to those
described at the beginning of this section. All missiles would be required to pass through a special verification facility to be examined, counted, and tagged. A perimeter-portal monitoring scheme around declared SLCM production and maintenance facilities would assure that all SLCMs entering or leaving these sites eventually made their way to the special verification facility. Within such a framework, any number of restrictions on these SLCMs could be required. For instance, there could be separate ceilings on the allowed number of nuclear and conventional cruise missiles. All conventional missiles might be required to conform to a design standard making it difficult to convert them quickly to nuclear cruise missiles. All but a few hundred cruise missiles might be required to be too large to fit into torpedo tubes on submarines.

Such an inventory limits scheme must be complemented by some deployment or launcher limits scheme. Otherwise there would be virtually no control over the deployment of SLCMs from undeclared facilities. These simple inventory limits are useful because they make the other treaty provisions more effective. The fact that tagging missiles frees inspectors on board ships from carrying radiation detectors is only one example. These inventory limits also make stockpiling missiles for a breakout more difficult because the stockpiles and their production facilities must be covert. This does not make cheating impossible; it just makes it more expensive and risky. Fundamentally, such simple inventory limits must be justified on the same grounds as the deployment limits schemes. It is acceptable to risk a SLCM breakout within the context of the other nuclear forces allowed in START to obtain the other benefits provided by START, and to retain the ability to deploy conventional cruise missiles.

Strict inventory limits on cruise missiles could prevent a rapid breakout. They would, however, be very hard to verify. To understand the extent of the problem, consider what the verification for such a regime would require. As for the simple inventory limits, missiles from declared sites would be examined, counted, and tagged. Additionally, inspectors stationed at chokepoints in the cruise missile logistics chain would determine that all missiles passing through these points had been legally tagged. These chokepoints must be areas that all missiles (or at least sample missiles from each production line) must necessarily pass, and that are readily identifiable.

Figure 2 shows a schematic of a cruise missile logistics train. It is based on the experience of U.S. SLCMs. The path for Soviet SLCMs is
undoubtedly somewhat different, although its gross characteristics are probably similar. After being produced, a missile can be flight tested or placed into storage. If the weapon is to be nuclear-armed, it first travels to a nuclear warhead mating facility. Once in storage, the missile can be deployed on a ship or submarine, or returned to a depot or factory for maintenance. Deployed missiles are periodically returned to storage for subsequent maintenance or, perhaps, flight testing.

The difficulty is that there are no good chokepoints in the cruise missile logistics train at which to intercept illegal SLCMs. It is possible, as we have seen, to inspect deployments of SLCMS on ships and submarines. However, illegal missiles need not be deployed until the breakout actually occurs. Cruise missile test ranges, production, storage, and maintenance facilities are very difficult to detect. To gauge the extent of the problem, it is useful to compare the difficulty of identifying the facilities associated with cruise missiles with those associated with mobile ballistic missiles. Monitoring inventories of these latter items is also a substantial obstacle in START.

The verification of any ceilings on mobile ballistic missile inventories in START will probably concentrate on facilities associated with the first stage rocket motors. These are large cylinders (the Pershing II first stage is 3.7 m long, 1.0 m in diameter, and weighs 4.2 metric tons) containing volatile rocket fuel. Because
of the danger of explosion, they are manufactured and stored at special facilities. In contrast, cruise missiles are smaller (the Tomahawk is 6.4 m long, 0.53 m wide, and weighs 1.5 metric tons) and less volatile.\textsuperscript{15} They can be manufactured and stored at facilities virtually indistinguishable from other light industrial plants. Thus, national technical means and other remote means of gathering intelligence would have a much easier task of identifying potential production and handling facilities for ballistic missiles than they would the facilities associated with cruise missiles.

Flight test ranges are important chokepoints for mobile ballistic missile verification. Identifying such sites is much easier for ballistic missiles than for cruise missiles. National technical means and other assets have a good chance of identifying ballistic missile test ranges. These missiles have guidance systems with range-dependent accuracy and thus must be flight tested to nearly their full range. Their rocket motors release large amounts of heat and light and are very difficult to hide from space-borne sensors. In contrast, cruise missile guidance systems have range-independent accuracy\textsuperscript{16} and can be tested over a small area. Cruise missiles are also built to be hard to detect by nearby air defenses. Their tests are very difficult to detect with sensors in space.\textsuperscript{17} These factors eliminate flight tests as a useful chokepoint for a cruise missile inspection regime.

Lacking reliable chokepoints, an inventory limits scheme capable of detecting covert cruise missiles would have to rely on broad, highly intrusive inspections. Because cruise missile facilities have few, if any, distinguishing features, inspectors would have to be given access to a wide range of industrial and military facilities in the United States and Soviet Union. The cost of such inspections is likely to be severe. These include not only the intelligence information that might be sacrificed, but also the disruption of operations and the monetary cost of preparing sites to be inspected and maintaining the inspection teams. Not only military but commercial operations would be affected.\textsuperscript{18} Even if the Soviet Union were willing to enter into such an inspection regime, it is not clear the United States should agree. The Soviets might reap greater benefits in military intelligence since

\textsuperscript{15}The Pershing II and Tomahawk characteristics are taken from the Memorandum of Understanding for the INF treaty, Sec.VI, Technical Data.

\textsuperscript{16}See the discussion in Footnote 3 of Sec. III.

\textsuperscript{17}If such a test were observed, it would probably be because of detection of telemetry, test equipment, or test operations, not the missile itself.

\textsuperscript{18}A similar problem would be faced in an inspection regime for a chemical weapons treaty in which the required inspections of U.S. chemical plants could reveal trade secrets.
they would have a better idea which facilities in the more open United States contain the most sensitive military information. The Soviets would certainly have the advantage in gaining any economically useful trade secrets that might be available to inspectors.

Thus strict inventory limits do not seem appropriate for controlling SLCMs within START. The nuclear SLCM threat is not serious enough to warrant imposing the necessary verification costs. In addition, a strict inventory limits regime would probably restrict both conventional and nuclear SLCMs, and ALCMs as well. It is too easy to convert conventional cruise missiles to nuclear ones, or to launch an ALCM from a ship, to justify strict inventory limits on nuclear SLCMs only. The ceilings must be low, because if they are high enough to allow substantial deployments of conventional cruise missiles, they will fail to restrict most conceivable Soviet nuclear SLCM threats. In the latter case they would offer no obvious benefits over the far easier to verify deployment limits schemes.

If the United States and Soviet Union continue to pursue strategic nuclear arms control to ceilings below START, the nuclear SLCM breakout threat will eventually become a matter of serious concern. Other than a severe launcher limits scheme that sets low ceilings on the number of allowable SLCM-capable launch tubes (including torpedo tubes) on ships and submarines, some sort of strict inventory limits scheme will become necessary. The large costs of verifying such limits on cruise missiles and the restrictions such limits would put on conventional cruise missile capabilities leads me to suggest that an alternative, strict inventory controls on nuclear warheads and material, also be explored.

Such a regime would place ceilings on the number of nuclear warheads and the amount of nuclear material each superpower could legally possess. There are enormous difficulties with such a scheme. Nonetheless, the indicators that a particular facility is associated with nuclear weapons may be more observable than the indicators that a facility is associated with cruise missiles. This certainly seems to be the case for facilities that produce nuclear materials. Inventory limits on nuclear warheads and materials would also allow unfettered conventional cruise missiles. In addition, there are numerous dual-capable nuclear and conventional platforms, from tactical aircraft to artillery, that inventory limits on nuclear warheads and material might free from restrictions under future nuclear arms control regimes.
These inventory limits, of course, present serious difficulties. Although it is difficult to maintain covert nuclear materials production facilities in a regime in which suspect site inspections are allowed, covert nuclear weapons production and storage may well be possible. Previous stockpiles of Soviet nuclear materials, unknown to the United States at the time of entering into such a treaty, would be a critical problem. In addition, there are four asymmetries that seem to favor the Soviet Union in such a regime. First, the Soviet civilian and military nuclear programs are more closely linked than in the United States. The U.S. programs are in fact legally required to be separate. Second, the United States has a smaller nuclear weapons program and production capabilities. These two factors indicate the United States would be forced to monitor more sites and more material than would the Soviet Union in any such arms control regime. Third, U.S. nuclear weapons require tritium to achieve their design effectiveness while the Soviets’ weapons probably do not. Since tritium decays with a half life of about a decade, stockpiled U.S. warheads, if unreplenished, would lose their effectiveness faster than those of the Soviets. Fourth, U.S. weapons require more testing to maintain the effectiveness of their designs than do Soviet weapons. These last two factors indicate that weapons covertly stockpiled by the Soviet Union would last much longer than any weapons stockpiled by the United States.

In spite of these problems, inventory limits on nuclear weapons and materials may be an option the United States will have to consider if it desires to reduce the numbers of strategic nuclear weapons significantly below the ceilings envisioned in START. In such a regime, this option may be the only alternative to banning all cruise missiles or severely restricting cruise-missile-capable launchers and platforms. The United States may not desire to limit such platforms because it values their conventional roles. Likewise, it may not desire to ban cruise missiles because it may conclude that the conventional variants are too important, especially in a world with a reduced number of nuclear weapons. Alternatively, the United States may decide that cruise missile inventory limits are even harder to verify. In either case, inventory limits on nuclear materials and weapons may be the best option.

19 I am indebted to RAND colleague Kenneth Solomon for helpful discussions on these points.
VI. CONCLUSIONS

The primary U.S. interest in limiting nuclear cruise missiles in START is to obtain Soviet agreement on limits on other types of weapons. Only secondarily is the United States interested in limiting the number of Soviet nuclear cruise missiles. Thus, the U.S. criterion for a good agreement on cruise missiles is one that is verifiable and has minimal costs. It should allow large deployments of conventional cruise missiles, avoid operational restrictions on military forces, and not be too difficult to verify.

The recommendations of this report, designed to meet these criteria, are summarized in Table 3, which also includes, in italics, options that are most useful if strategic nuclear arms limitations are continued to treaties with ceilings well below START's. There are three general categories of options: deployment limits restricting the cruise-missile-capable launchers that can legally carry nuclear cruise missiles; launcher limits restricting the number of cruise-missile-capable launchers; and inventory limits restricting the number of cruise missiles (or other treaty accountable items) each side can legally possess. Inventory limits can either have simple, and thus not costly, verification schemes that make no attempt to detect production and storage of cruise missiles from undeclared facilities, or they can have stringent and costly verification designed to detect such activities.

The recommended means of limiting nuclear cruise missiles on bombers is a simple modification of the current START framework and is a combination of deployment and launcher limits. As currently agreed, bombers carrying nuclear cruise missiles would count toward the START nuclear warhead and delivery vehicle ceilings. To allow conventional cruise missiles, the treaty would define a separate class of dedicated conventional bombers and prohibit the deployment of nuclear weapons on these aircraft. Short notice, on-site challenge inspections would certify that these conventional bombers were not nuclear armed. Such a scheme could prevent large covert deployments of nuclear cruise missiles on these bombers. Simple inventory limits on nuclear cruise missiles would help limit the size of potential breakout, but the most important restriction would be separate ceilings on the number of allowed dedicated conventional bombers.
### Table 3

**RECOMMENDATIONS**

<table>
<thead>
<tr>
<th></th>
<th>Deployment Limits</th>
<th>Launcher Limits</th>
<th>Inventory Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bombers</strong></td>
<td>No nuclear weapons on dedicated conventional bombers</td>
<td>Counting rules on nuclear bombers, separate ceilings on dedicated conventional bombers</td>
<td>Simple: Ceilings on all nuclear cruise missiles&lt;br&gt;Stringent: Ceilings on all nuclear cruise missiles</td>
</tr>
<tr>
<td><strong>Surface ships</strong></td>
<td>No nuclear SLCMs on ships&lt;br&gt;Only tagged SLCMs on ships</td>
<td>Ceilings on SLCM-capable launchers</td>
<td>Simple: Ceilings on nuclear cruise missiles&lt;br&gt;Stringent: Ceilings on all nuclear warheads</td>
</tr>
<tr>
<td><strong>Submarines</strong></td>
<td>No limits on torpedo-tube-launched SLCMs; no nuclear or untagged VLS SLCMs&lt;br&gt;Only tagged SLCMs on subs</td>
<td>Ceilings on SLCM-capable launchers&lt;br&gt;Ceilings on all SLCM-capable launchers</td>
<td>Simple: Ceilings on nuclear cruise missiles&lt;br&gt;Stringent: Ceilings on all nuclear warheads</td>
</tr>
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</table>

**NOTES:** Entries in italics are not useful for START.<br>Simple inventory limits make no attempt to detect production and storage from undeclared facilities. Stringent inventory limits include highly intrusive inspections to detect such activities.
On surface ships, nuclear cruise missiles are best restricted by deployment limits. Either nuclear cruise missiles could be banned from these vessels or, in the context of simple inventory limits on nuclear cruise missiles, only properly tagged cruise missiles could be allowed. These provisions would be verified by inspections of SLCM-capable launchers while the ships are in port. Equipment capable of reloading these launchers at sea would be banned, or the inspections would have to include magazines as well. Such a scheme is vulnerable to breakout. Simple inventory limits on nuclear cruise missiles could marginally increase the cost and risk of preparing a breakout. However, the main reason these deployment limits are justified is that a nuclear SLCM breakout is not of sufficient concern for the United States to warrant more stringent SLCM controls or to give up the other benefits of START.

There are two deployment limits schemes for restricting nuclear SLCMs on submarines. The simpler is to ban nuclear or untagged SLCMs in vertical launch tubes, similar to the provisions for surface ships, and ignore any SLCMs carried for launch through the torpedo tubes. This latter provision may be sufficient because submarines have small magazines that mostly carry torpedoes, so the total number of nuclear SLCMs that can be reasonably launched through the torpedo tubes of each side's submarines is no more than several hundred. The second and more complex option would be to ban untagged SLCMs from submarines. Such a provision would be verified by inspections of the weapons being loaded and unloaded from submarines in port. In other particulars this scheme is similar to the deployment limits for surface ships. In addition, the launcher limits scheme of placing a ceiling on the total number of vertical launch tubes could be useful.

In a treaty that reduced the number of strategic nuclear weapons to ceilings substantially below START’s, preventing a nuclear cruise missile breakout might become a serious concern. Such a treaty would have to either restrict the number of cruise-missile-capable launchers (including torpedo tubes and all cruise-missile-capable heavy bombers) or apply stringent inventory limits. Since any long-range conventional cruise missiles can be converted to a long-range nuclear cruise missile within a few days to weeks, it is not sufficient to limit only nuclear cruise missiles. Any cruise missile inventory limits must restrict conventional cruise missiles as well. Neither these launcher limits nor stringent cruise missile inventory limits would allow large deployments of conventional cruise missiles. In addition, inventory limits on conventional cruise missiles would be
exceedingly difficult to verify. A potential alternative is inventory limits on nuclear warheads and materials, which may be easier to verify than cruise missile inventory limits and would obviate the need for restrictions on not only conventional cruise missiles, but the full range of dual-capable platforms, in a treaty with very low ceilings on strategic nuclear weapons.
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