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VERIFIED DISPOSAL OF NUCLEAR WARHEADS

No nuclear warheads have yet been eliminated by treaty. The INF Treaty calls for verified destruction of specified missiles, but the warheads on those missiles are returned to each country, without restrictions. Similar conditions are expected to apply to the START Treaty to reduce the numbers of US and Soviet deliverable strategic missile warheads. Nevertheless it is reasonable to hope and expect that destruction of strategic and tactical nuclear warheads, not just the means for their delivery, will be called for sometime in the future.

The prospect has led to a number of studies, including one by the FAS-CSS Cooperative Research Project focused on procedures to verify the elimination of nuclear warheads that, under treaty, have been specified and made available for dismantlement and controlled disposition of their fissile materials (plutonium or highly enriched uranium).

This study does not deal with methods to assure that all warheads specified by a treaty have actually been disclosed. Nor does it consider possible methods to prevent production of new warheads, using undisclosed stockpiles of fissile materials, of the types specified for elimination. Such assurances will require additional verification methods, and these can be expected to become more important as deep cuts in nuclear arsenals increase the strategic importance of any hidden stockpiles of nuclear warheads or fissile materials. The issue is being examined in a second phase of the FAS-Committee of Soviet Scientists joint project.

Protecting Nuclear Weapon Design Secrets

One of the reasons given for not including elimination of warheads in the INF or START treaties is a presumption that verification cannot be done without revealing important secrets about the design of the warheads or other associated equipment, such as re-entry vehicles, penetration aids, or shielding against radiation that might be used to disable the warheads. A major constraint on the procedures described here, therefore, is that they not reveal such information.

Two levels of secrecy can be distinguished. The first involves information that the United States and the Soviet Union (and other announced nuclear weapon states) do not want to reveal to each other. The second is information that may be well known to parties to a treaty calling for warhead elimination, but is not generally public—including information that could significantly help other countries in their efforts to acquire nuclear weapons. Public disclosure of such information could be regarded as violating the Non-proliferation Treaty, which calls on nuclear weapon states that are signatories not to transfer nuclear weapon technology to other countries.

Two further assumptions about secrecy are inherent in the proposed process for eliminating warheads.

The first is that the *aggregate* quantities of uranium-235, uranium-238, and plutonium of any isotopic composition that are contained in a *mix* of several different types of warheads can be declassified, in the course of future treaty negotiations. This would allow accurate accounting for fissile materials removed from the warheads, without revealing the quantities in any particular kind of warhead.

The second assumption is that upper limits to some of the material quantities, component weights, and dimensions associated with the warheads can be declassified, without compromising national security, provided that the upper limits are sufficiently large compared with the actual values. Then each owner nation could mask the true value of quantities it wished to keep secret by adding appropriate items, in unrevealed amounts, to containers used for the warheads before they are dismantled.

Functions of a Warhead Elimination Process

A system for the elimination of nuclear warheads should ensure that:

1. All warheads identified by the owner country, and specified for elimination, are what they are claimed to be.
2. All such warheads are destroyed.
3. None of the fissile materials from the dismantled warheads is diverted to uses that are not authorized by treaty.

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FAS-Soviet Joint Research Project

The articles in this issue are largely based on work done by the Cooperative Research Project on Arms Reductions of the FAS Fund and the Committee of Soviet Scientists for Peace and Against the Nuclear Threat. The Project has, for the past two years, been conducting research on the verifiability of deep cuts in the US and Soviet nuclear arsenals, of a ban on nuclear reactors in earth orbit, and of a ban on laser anti-satellite weapons.

The present authors, Theodore Taylor and Valerie Thomas, are also contributors to a book prepared by the Project, *Reversing the Arms Race: How to Achieve and Verify Deep Reductions in the Nuclear Arsenals.* Co-edited by Frank von Hippel and Roald Sagdeev, the book will be published this summer by Gordon and Breach Scientific Publishers and will be offered to FAS members at a discount. ■

Cutting Naval Tactical Nuclear Weapons—page 5

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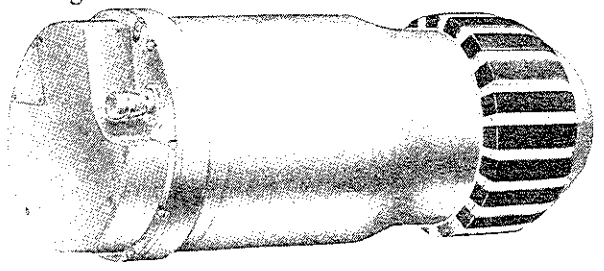
Steps in the Warhead Elimination Process

The process for verified elimination of specified warheads is an application of the "Principle of Containment." All steps in the process are carried out within specified boundaries that are monitored to assure detection of any unauthorized removal of warheads or their components, especially fissile materials, from these boundaries.

The first step in this process is taken at the warhead deployment or storage sites. In the presence of inspectors, the warheads are removed from delivery vehicles or storage facilities and placed in containers. Each container, which may hold more than one warhead of the same type (e.g. a MIRV system), is tagged and sealed by inspectors.

The tags, which cannot be changed without revealing the tampering, serve as unique identifiers of each warhead or container. The seals will reveal if the containers are subsequently opened to substitute fake warheads or other objects for the original contents.



W-80 type warhead, used in US cruise missiles

The sealed and tagged storage containers are then shipped to a warhead dismantlement facility in the owner country. As the containers are unloaded they are externally examined by inspectors to assure that the tags and seals have not been tampered with. Records of shipments from the deployment or storage sites are compared with records of arrival at the dismantlement facility, to assure that all containers are accounted for before they are placed in storage to await dismantlement. The entire dismantlement facility is subject to the containment principle.

Fingerprints for Verification, Batches for Secrecy

Batches of specified numbers of containers for several different types of warheads are then removed from storage, and moved to an enclosed facility that is used for the actual dismantlement process. The ratios of numbers of each type of warhead in a batch are kept constant, to keep inspectors from deducing any secret information about individual warhead types from aggregate data from batches with different ratios of warheads of different types.

Before dismantlement starts, each container is "fingerprinted" by inspectors, without opening the containers. This is done by accurate scanning of the interior of the containers, using radiation emitted from warhead materials (passive scanning) or secondary radiation produced in the interior after irradiation with an outside source (active scanning). Other accurate measurements, such as the total weights of the loaded containers or their moments of inertia, can also be

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used to determine a fingerprint.

The raw data from which each fingerprint is derived should be combined in ways that yield accurate numbers that are recorded by inspectors, but that do not reveal design data that is to be kept secret. Warhead design details could be further obscured by allowing the owner country to place unrevealed additional materials in each container before it is loaded with warheads. The amounts and configurations of any added materials would be kept the same for each type of warhead.

The fingerprints can thus assure that the contents of containers of warheads of a particular type are the same. Any substitution of fake for real warheads, before they are tagged and sealed, would have to be made for all the warheads of a particular type, and the substitutions would have to be completed before any inspection of the deployment or storage sites. Such action would run the risk of being detected by national intelligence activities before or soon after a treaty comes into force, or eventually, because such an operation would involve many people, any of whom might reveal this blatant an act of cheating at some later time. The risk of eventual discovery could be increased by a treaty provision that randomly chosen warheads alleged to be of some specific type be placed in long term, sealed storage, for possible detailed examination by inspectors at some unspecified future time.

Owner Country Does Actual Dismantlement

All the warheads in each batch of mixed containers are then dismantled by nationals of the owner country, inside an enclosure that is subject to the containment principle, but not to inspection during the dismantlement process. The non-nuclear components are destroyed by nationals of the owner country, inside an adjoining enclosure. The dismantlement facility could be inspected between batch dismantlements, to assure that no stockpiles of fissile materials have been hidden.

The fissile materials contained in a batch are mixed without inspectors present, and then made available to inspectors for accurate measurements of their total mass. This will not reveal the quantities used in any particular type of warhead. These measurements provide the initial basis for detailed accounting of the plutonium and highly enriched uranium as they flow through subsequent steps.

Depending on treaty specifications, any contained tritium is either returned to the owner country (to be used to replenish decayed tritium in other warheads not yet subject to elimination, or for use in future fusion reactors), or stored in a contained area until most of it has decayed (half life = 12.6 years). In either case, even the batch total may remain secret, so measurement by inspectors of the quantities of tritium would not be required.

All objects (including empty warhead containers) and bulk materials removed from the dismantlement facility are probed with external neutron sources to assure that they contain no fissile materials. Any residues from the destruction of the non-nuclear components of the warheads are also inspected with external probes before they are shipped from the dismantlement site for ultimate disposal.

Disposition of Fissile Materials from Warheads

The highly enriched uranium removed from the warheads can be rendered incapable of sustaining an explosive chain reaction by diluting it with natural or depleted uranium until the uranium-235 enrichment is less than 6 percent. At an enrichment of about 3 percent, the diluted uranium could be used as feed material for fuel for nuclear power plants.

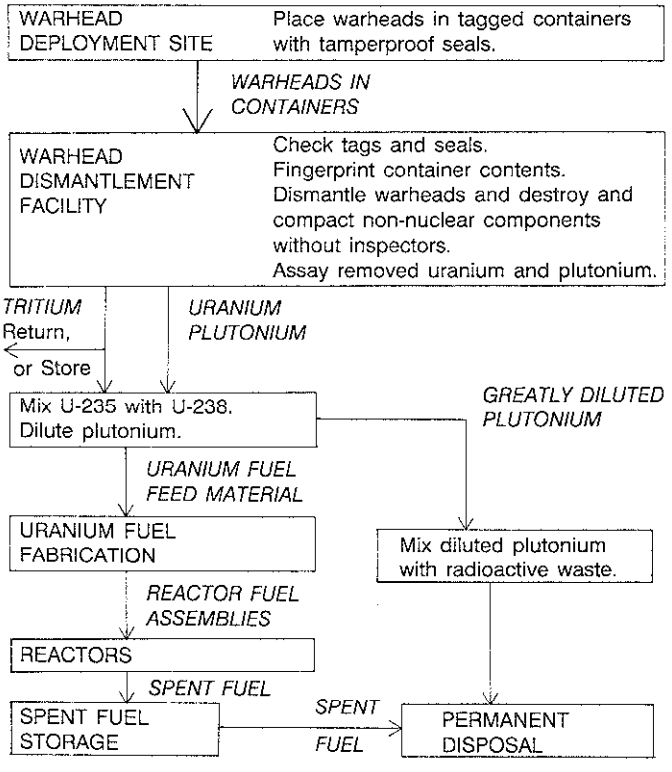
This material would be kept under IAEA safeguards until ultimate disposal of spent fuel from the reactors in which it may be used. The approximately 1,000 tons of highly enriched uranium associated with the world's present nuclear warheads could provide fuel for the world's present power reactors for about 5 years. This could save an estimated $30 billion dollars in future nuclear fuel costs.

If, for whatever reasons, world nuclear power production declines sharply, the highly enriched uranium could be diluted with depleted uranium, to bring its enrichment down close to that of natural uranium, and disposed in a geological formation or, perhaps, dissolved in the ocean.

The Plutonium Problem

The plutonium extracted from nuclear warheads cannot be diluted with plutonium isotopes to render it nonfissile, since all plutonium isotopes are capable of sustaining a fast chain reaction. The use of this plutonium to supplement uranium-235 in nuclear power plant fuel would require expensive modification of the fuel fabrication facilities now used for making uranium fuel. These facilities, and the transport links between them, would then present opportunities for diversion or theft of plutonium.

Whereas the isotopic enrichment of natural or low-enrichment uranium to produce weapon-grade uranium-235 is a



Steps in the proposed warhead dismantlement process

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difficult process requiring extensive equipment and energy, it is relatively easy to extract plutonium for use in nuclear explosives by chemical means. It would also be much easier to do this from plutonium-supplemented uranium reactor fuel than to extract plutonium from extremely radioactive spent nuclear fuel.

A much safer alternative would be to dispose of the plutonium directly, without using it as fuel. Pending a satisfactory method for ultimate disposal of the transuranic elements and fission products in spent fuel, the plutonium from warheads would have to be stored, probably in facilities that are under international authority and subject to the containment principle and high levels of physical security.

Before placement in storage, however, the plutonium should be mixed with appropriate materials to assure that the mixture cannot, in any large quantity, sustain any type of fission chain reaction. For an infinite mass of the mixture to remain sub-critical, the types and concentrations of the added materials should be such that neutron capture is sufficiently more likely than fission. Candidate materials include cadmium, boron, and tungsten, and preliminary estimates indicate that the added materials could have roughly the same total mass as the plutonium.

All nuclear material products of the warhead dismantlement process would have to be kept under stringent international safeguards, such as extensions of those now set up and maintained by the IAEA, until the uranium and plutonium have been permanently disposed of by methods that would make retrieval very difficult. Facilities for storage of warheads awaiting dismantlement, or plutonium awaiting final disposal would also need to be securely guarded against theft or any attempt to take over control of the facilities.

This function might be appropriate for a UN security force with much greater related authority than is now given to the IAEA, which plays no direct role in maintaining physical security of nuclear materials under its safeguards, which are designed only to *detect*, rather than to *prevent* diversion of the materials to destructive purposes.

Connection with a Fissile Material Production Ban

Actual demonstration of the above or similar procedures would not necessarily require a treaty calling for elimination of large numbers of nuclear warheads. But such a treaty, if it calls for eliminations of the contained fissile materials, would only make sense if a ban on further production of fissile materials for warheads were also in force.

Verifying such a treaty between acknowledged nuclear-weapon-states has been extensively studied. The conclusions are that such verification can be achieved with high assurance, provided that all the existing military plutonium production reactors are disclosed and shut down, and existing uranium enrichment plants that can produce high enrichment materials suitable for nuclear warheads are either shut down or placed under bilateral, multilateral, or international safeguards to assure that they do not produce material for nuclear warheads.

Production of limited quantities of highly enriched uranium might be allowed, for some specified time, to supply fuel for nuclear propulsion of military surface ships or submarines. Arrangements for verifying that this material is not secretly diverted to use in nuclear explosives would have to be devised.

A ban on production of fissile materials for nuclear explosives might extend to a ban on production of tritium for weapons. Tritium in warhead stockpiles would decay at a rate of about 5% per year. If agreements were made to eliminate nuclear warheads at a rate faster than this, and if extracted tritium were returned to the owner country, remaining warheads not slated for elimination could, on the average, be replenished with recycled tritium.

Next Steps

These studies indicate that elimination of identified nuclear warheads can be verified with high confidence, without revealing national secrets. Much remains to be done, however, to specify the procedures in sufficient detail to provide a basis for negotiated protocols and the means for carrying them out.

Two consecutive next steps are therefore proposed:

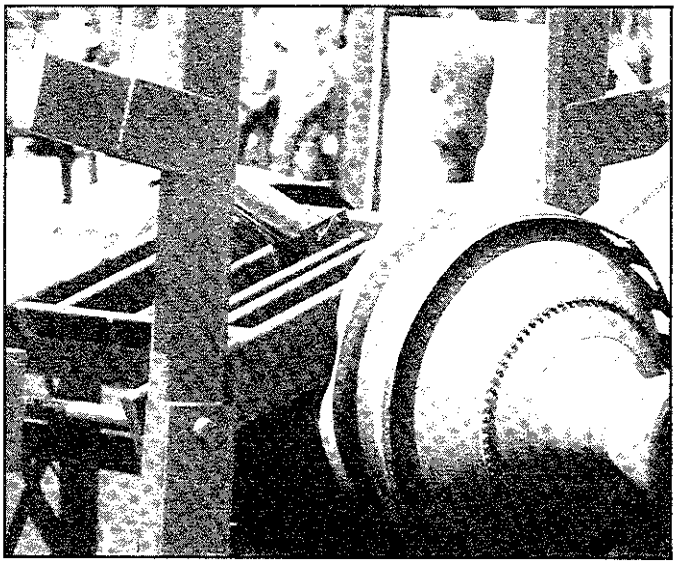
The first is the establishment of an official joint US-Soviet working group to design and assess specific procedures and facilities for verified elimination of nuclear warheads. Work by this group should be given high priority by both nations and not require negotiation of further treaties.

The second step is to carry out joint US-Soviet demonstrations of the techniques identified in the first step. These demonstrations would be expected to include some field testing of parts of a warhead dismantlement and verification system. Initial tests could be performed using unclassified mockups of warheads. These could be followed with complete system tests, using batches of several types of warheads from each nation.

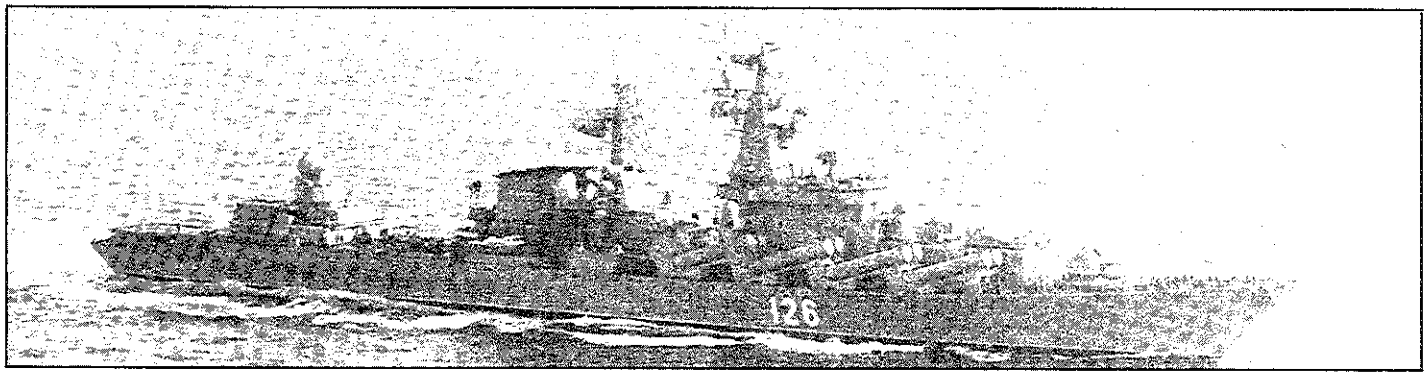
The FAS-Soviet Cooperative Research Project is continuing its effort to lay a basis for and promote a government-to-government cooperative project on this problem.

— Theodore Taylor □

Dr. Taylor is a former nuclear weapons designer and a consultant on problems of arms control.



Rocket motor being verifiably destroyed in compliance with the INF Treaty. Can we do the same with nuclear warheads?



A Soviet Slava*-class guided missile cruiser, with horizontal sea-launched cruise missile (SLCM) launch tubes visible on deck*

REDUCTIONS IN TACTICAL NAVAL NUCLEAR WEAPONS

Tactical naval nuclear weapons (all naval nuclear weapons except sea-launched ballistic missiles) are the only nuclear weapons for which negotiations are neither underway nor planned. Even among arms control specialists there has been little discussion of how reductions in this class of weapons might be carried out.

The Soviet Union has pushed for limiting long-range nuclear sea-launched cruise missiles (SLCMs) under the START treaty, and for negotiated reductions in all naval tactical nuclear weapons. But because of US resistance, it seems that the START agreement will not limit SLCMs, although "politically" binding declarations of planned deployments will be made. The United States is phasing out nuclear anti-submarine and anti-aircraft missiles, but has shown no interest in negotiations negotiations on other tactical naval nuclear weapons. Nevertheless, if US-Soviet relations continue to improve, further reductions in naval nuclear weapons will become increasingly likely.

Three approaches to reductions in these weapons are discussed here: unilateral reductions of older weapons; negotiated reductions of ship-and submarine-launched tactical nuclear weapons (about half of all tactical naval nuclear weapons); and negotiated reductions in all tactical naval nuclear weapons, including those carried by aircraft. Because of the difficulty of monitoring *naval* aircraft-carried weapons as a separate category, reductions in all naval tactical nuclear weapons are discussed in the context of a comprehensive treaty covering all nuclear weapons.

Approach I: Unilateral Reductions

Though not interested in negotiated reductions, the US is unilaterally eliminating its 1960s-era nuclear ASROC and SUBROC anti-submarine rockets and Terrier ship-to-air missiles, a reduction of about 30% percent in US tactical naval nuclear weapons. Although these weapons were due for retirement, no replacements for them are planned.

These reductions reflect the diminishing role of US naval tactical nuclear weapons. Admiral Carlisle Trost, chief of naval operations, said, "The Navy . . . has been reducing its reliance on nuclear weapons over the last decade . . . We have foregone the development of replacements for several of these weapons simply because we put our effort into more accuracy in weapons placement and better design." Referring to use of nuclear weapons against ships, Captain Linton Brooks, who was the director of arms control on the National Security Council, said "the US Navy gains relatively little from the ability to employ nuclear weapons at sea . . . "

However, this thinking does not seem to apply to nuclear SLCMs, which would attack land targets, nor to bombs, new versions of which are in production and development.

The Soviet Union has made few unilateral cuts, and has many older naval weapons thought to carry nuclear warheads, including the SS-N-3, -7, -9, and -12 SLCMs; nuclear torpedoes; the SS-N-15 anti-submarine rocket; the FRAS-1 anti-submarine rocket; the AS-2, -4, -5, and 6 air-to-ship missiles; and probably several types of bombs.

The Soviet Union might determine that these weapons are no longer useful, and eliminate some or all of these weapons unilaterally. Elimination of all of them would amount to about a 70% reduction in Soviet tactical naval nuclear weapons, yet would still leave the Soviet Navy with 3 types of SLCMs, an anti-submarine rocket, and nuclear bombs, all relatively recently deployed.

Cuts in old weapons would be an easy first step in naval nuclear reductions. Of course, neither the United States nor the Soviet Union need restrict unilateral cuts to their old or obsolete weapons.

Approach II: Negotiated Reductions in Ship-and Submarine-Launched Nuclear Weapons

Negotiated reductions in or elimination of tactical naval nuclear missiles (that is, weapons launched from ships and submarines) would be more difficult to implement than unilateral measures, but a treaty has the advantages of being binding, bilateral, and subject to verification.

For the US, "naval tactical nuclear missiles" would include only the nuclear SLCM (20% of US naval tactical nuclear weapons); for the Soviet Union, it would also include nuclear anti-submarine rockets, surface-to-air missiles, and torpedoes (about 60% of the Soviet weapons). Negotiated reductions in different types of tactical naval missiles can be considered together because the missiles have similar verification problems. These problems have been widely discussed for sea-launched cruise missile verification; the primary issues involve the intrusiveness of inspections on ships and submarines.

Of course, the most direct approach to monitoring deep

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reductions in or elimination of tactical missiles is to observe and monitor their destruction. This need not involve any inspections of ships or submarines. Ideally, it would include destruction of the nuclear warheads, with the fissile material put under safeguards for permanent disposal or use in civilian power reactors (see Taylor, this issue).

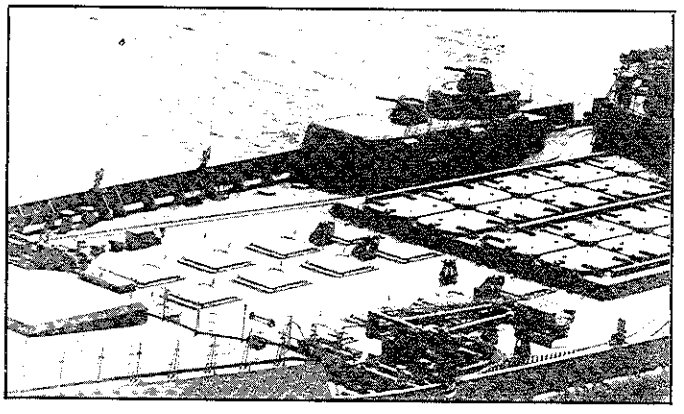
However, not all missiles might be turned in for destruction. New ones might be manufactured. To address these concerns, a continuing monitoring system would be needed.

The direct approach to monitoring *deployed* missiles would be through periodic inspections of missile launchers and storage areas on ships and submarines. If the missiles were not banned, the treaty could specify the number of each type of nuclear missile allowed on each ship or submarine. Inspections would be made at ports, on a challenge basis. Since the inspecting side could choose which ship or submarine to inspect, the total number of inspections per year need not be large.

Verifiability Characteristics of the Weapons

Tactical missiles have characteristics which make verification difficult. Since many of these weapons have both nuclear and non-nuclear versions, close inspection would be needed to distinguish them. In some cases the radiation from the warhead itself could be a reliable indicator of the presence of a nuclear version, but in other cases more intrusive measures may be needed. Some of these weapons (nuclear torpedoes, anti-submarine rockets, and some SLCMs) can be launched from submarine torpedo tubes, so inspections inside submarine torpedo rooms would be needed to monitor deployment directly.

However, these tactical missiles also have characteristics which assist verification. With the exception of torpedo tube weapons, all of the missiles and launchers can be counted from the exterior of the ship or submarine, reducing the monitoring problem to one of distinguishing nuclear from non-nuclear weapons in a fixed number of launchers. These missiles are not easy to transfer onto ships and submarines, and they are too large to be stored in all but a limited number of places on ships, so any inspections of deployed weapons could for the most part be limited to the vicinity of the launchers. With the exception of torpedo tube weapons, the contents of launchers could be checked in ports without internal inspections of ships or submarines. And even inspections for torpedo tube weapons need not entail inspection of the entire submarine, but only of the torpedo room and its access route.



Vertical launch tube hatches clearly visible on Soviet Kirov*-class cruiser. Verification can be done from deck, without intrusion.*

UNITED STATES		SOVIET UNION	
Sea-launched cruise missiles			
Tomahawk	367	SS-N-24	0?
		SS-N-22	25?
		SS-N-21	50?
		SS-N-19	55?
		SS-N-12	45?
		SS-N-9	80?
		SS-N-7	45?
		SS-N-3	100?
			400?
Ship- and sub-based anti-submarine warfare			
ASROC (retired)	0	FRAS-1 rocket	25?
SUBROC (being retired)	200	SS-N-15	200?
		SS-N-16	200?
		torpedoes	450?
			875?
Ship-based anti-aircraft missiles			
Terrier (retired)	0	SA-N-1, SA-N-3, SA-N-6	250?
Aircraft-carried weapons			
B-43 bomb, B-57 strike bomb, B-61 bomb	850	AS-2 missile, AS-4 missile, AS-5 missile	450?
B-57 ASW bomb	825	AS-6 missile	
Depth/strike bomb (planned)	0	Depth bomb	400?
		Bombs (800 aircraft)	X
	1675		X + 850?
Estimated Totals			
	2200		X + 2400?

Estimates of US and Soviet naval tactical nuclear weapons

"Neither Confirm Nor Deny"

The United States is opposed to allowing any Soviet inspections of ships and submarines, both because the US does not want to reveal ("neither confirm nor deny") which ships and submarines are carrying nuclear weapons, and because of general security concerns. Security and espionage concerns could be addressed by restricting inspections to the vicinity of the launchers, by shrouding unrelated equipment, and by other measures.

The "neither confirm nor deny" policy, however, is meant to create uncertainty as to which vessels are carrying nuclear weapons. The policy has the additional effect of finessing conflicts raised by US Navy port calls in allied nations which do not allow nuclear weapons in their ports. Obviously, this policy would be compromised by Soviet inspections for nuclear weapons on US ships and submarines.

The problem could be minimized if tactical nuclear missiles were eliminated entirely, or at least banned from surface ships, leaving only submarines and aircraft carriers as platforms for nuclear weapons at sea. Aircraft carriers are, already, prime targets and are widely assumed to carry nuclear

weapons, so "neither confirm nor deny" has little practical importance for carriers. And submarines are considerably less vulnerable to attack than surface ships; revealing which carry nuclear weapons would not significantly threaten their security or decrease deterrence.

Thus, the primary problems with revealing which vessels carry nuclear weapons under a naval nuclear reductions treaty would be matters of alliance diplomacy, rather than nuclear deterrence or military posture.

Torpedo Tubes

As mentioned above, torpedo tube weapons would require internal submarine inspections for direct verification of deployment. This is somewhat more involved than monitoring launchers on ship decks. Thus, if on-ship inspections are to be part of the treaty, one might think of exempting torpedo tube weapons from the agreement, or of exempting all nuclear weapons on submarines.

However, this would greatly weaken any treaty covering naval nuclear missiles, since it would exempt such a large proportion, and might even encourage deployment of more torpedo tube weapons. Since some nuclear SLCMs can be launched from both torpedo tubes and ship-based launchers, a treaty exempting torpedo tube weapons would not result in a strong limit on SLCMs. Indeed, the Soviet long-range SLCM is primarily a torpedo tube weapon.

A Comprehensive Monitoring System

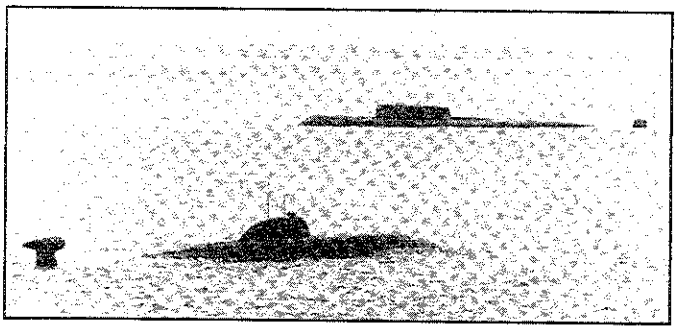
As noted above, the US Navy considers inspections of deployed missiles on ships and submarines to be unacceptably intrusive. Inspections could require removing the missile from its launcher, or other awkward procedures. And inspection of deployed missiles does not address the possible stockpiling of missiles.

An alternative approach which addresses these issues is to reduce or eliminate ship and submarine inspections in favor of a comprehensive monitoring system, beginning at the production facilities. Such a monitoring system would have the following elements:

- Each tactical missile would be brought to an inspection station, where it would be tagged for future identification.
- Tamper indicators ("seals") could be attached to non-nuclear versions to deter installation of a nuclear warhead. Any missiles not eliminated would be checked, retagged and resealed after major maintenance activities.
- Missile production facilities would be monitored; any new missiles would be inspected and tagged before deployment.

This scheme could be implemented without inspections on ships and submarines, that is, without direct monitoring of deployed missiles. However, provision for some challenge inspections of launchers would significantly strengthen the monitoring scheme. Baseline inspections during the initial phase of the treaty would be useful to verify that all missiles were declared. After the initial period, inspections could be sharply reduced or eliminated, so as to minimize the disruption of naval activities.

The life-cycle monitoring system described above could be implemented whether naval nuclear missiles were eliminated or just reduced. But verifiability of the treaty would be greater if all nuclear missiles of a given type were eliminated, and greatest if all naval tactical nuclear missiles were eliminated, since in these cases any activity associated with the production, storage, maintenance, movement or deployment of the weapons would clearly indicate a violation.



Submarine-based weapons pose a special problem: torpedo tubes would have to be monitored from interior of subs.

Approach III: Negotiated Reductions that Include Aircraft-Carried Naval Nuclear Weapons

The remaining category of naval tactical nuclear weapons are weapons delivered by aircraft, which includes both bombs and small air-to-surface missiles. These weapons comprise about 80% of US and perhaps half of Soviet tactical naval nuclear weapons. Most of the US weapons are based on aircraft carriers; most of the Soviet weapons are land-based and intended for attacks on US carriers.

Air-launched weapons are more difficult to monitor than tactical missiles because they are smaller, easy to transport, can be stored in many places on aircraft carriers or on land, and can be delivered by many types of aircraft. Many of these weapons are indistinguishable from nuclear bombs and small missiles used by the Air Forces; the US Navy has about 850 tactical nuclear bombs, and the Air Force has about 2500 bombs of the same types. Not even rough estimates of the number of Soviet bombs are available, but the Soviet Air Force and Soviet Naval Aviation have the same kinds of aircraft for nuclear missions.

Therefore monitoring of naval aircraft-carried nuclear weapons would be much more difficult than for missiles; a different kind of verification regime is needed.

Seeking a Verification Regime

The most straightforward method of verifying the elimination of or deep reductions in these weapons is to monitor dismantlement of the weapons and of the special facilities which stored and maintained them. Verified destruction of a large number of nuclear bombs would be strong evidence of treaty compliance.

However, other bombs and missiles might be substituted for those destroyed, since there are similar weapons in the Air Force arsenals, and new bombs could be manufactured. Aircraft-carried nuclear bombs could not be tagged for life-cycle monitoring, as proposed above for tactical missiles, because most bombs are produced in final form at the nuclear warhead production plants. Since all types of warheads are produced at these plants, and different types may not be

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easily distinguishable, life-cycle monitoring of these weapons could only be implemented if all nuclear warheads were subject to monitoring.

Therefore, in order to have a strong verification regime, reductions in aircraft-carried naval nuclear weapons should cover more than just naval weapons, and should include a comprehensive monitoring system.

Of course, a comprehensive nuclear warhead treaty would not be developed solely to verify reductions in naval nuclear bombs. All nuclear bombs and small nuclear weapons share the verification problems of naval bombs; these small weapons comprise between one-third and one-half of both US and Soviet nuclear arsenals.

A comprehensive treaty covering all nuclear weapons would make it possible to monitor the warheads themselves. An accounting system could be established as follows:

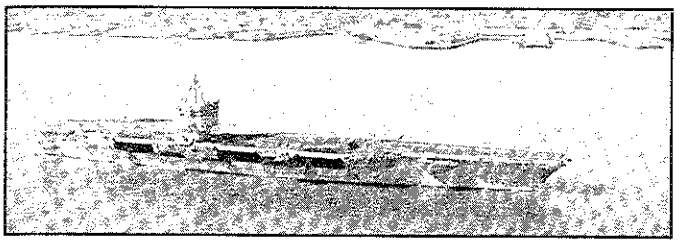
- Every warhead would be declared by type and location; each warhead would be "tagged."
- Warhead destruction would be monitored.
- Warhead production would be strictly limited, to allow only for replacement of old warheads on a one-for-one or less basis.

A treaty of this format involving ten-fold reductions in US and Soviet nuclear arsenals, to a maximum of 2000 nuclear warheads each, has been examined by the Joint Research Project of FAS and the Committee of Soviet Scientists.

Outlook Under Deep Reductions

If the US and the Soviet Union had "only" 2000 nuclear weapons each, in a regime of comprehensive limits on nuclear warheads, would any of the remaining warheads be in tactical naval weapons?

It is possible that some long-range nuclear SLCMs would be retained. These missiles are invulnerable if deployed on submarines, and could be viewed as more versatile than sea-launched ballistic missiles because they have only one warhead and can be deployed on most submarines. SLCMs could be monitored by the life-cycle monitoring system outlined previously.



Neither confirm nor deny? It's an easy guess.

However, SLCMs can be seen as highly destabilizing weapons, because their launch might not be detected by early warning systems. Perhaps nuclear SLCMs should be banned even while hundreds of SLBMs and ICBMs (which also have destabilizing characteristics) remain deployed. The advantage of keeping SLCMs is small, since their role is so similar to that of single-warhead SLBMs, which are considerably easier to monitor.

It is possible that some naval aircraft weapons would also be retained. The usefulness of these nuclear weapons for attacking ships and land targets, at least by the US Navy, is already in doubt, but perhaps anti-submarine bombs will remain highly valued.

If any aircraft-carried naval nuclear weapons were kept, it is likely that they would be multi-purpose weapons, for use in Air Force or Navy roles. Limits on these weapons could be verified if they were kept at special air bases subject to challenge inspections. This would allow the retention of weapons for "coastal defense" against submarines or surface ships. But it would be difficult to monitor these weapons if kept on aircraft carriers.

Overall, it is likely that naval tactical nuclear weapons would be cut very deeply to allow a larger proportion of strategic weapons to be retained. Complete elimination of tactical naval nuclear weapons could be driven by strategic, military and operational concerns; complete elimination would certainly be easier to verify. — *Valerie Thomas* ☐

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