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LETTERS & COMMENT

We welcome comments on articles and, more generally, on issues related to science and global security.

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USING SHIPBOARD INSPECTIONS TO MONITOR LIMITS ON SLCMS*

With respect to verification of limitations on long-range sea-launched cruise missiles (SLCMs), the subject of Valerie Thomas' paper (*Science & Global Security* 1, 1-2) it is important to emphasize that, contrary to much conventional wisdom, it would be very difficult to conceal SLCMs on ships if even relatively unintrusive on-board inspection of the ships were permitted.

This can be illustrated for US ships, where a ship's architecture is public information. It is often remarked that there is less available space on Soviet ships than on US ships—it appears likely that constraints on concealment would apply even more forcefully to Soviet ships.

For the US, the design of several categories of naval vessel and the physical characteristics of the Tomahawk (the US sea-launched cruise missile) limit how easily SLCMs can be concealed. An indication that this might be true follows from maintenance considerations on certain ships. There are mechanical parts that are vital to the function of a ship that are comparable in size to a Tomahawk and need to be replaced occasionally. For example, when a gas turbine engine on a ship fails, it is replaced in

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port by lowering it by crane through the top of the main smoke stack. Furthermore, when a main reduction gear of a propulsion system fails, the disabled ship is returned to port, placed into drydock, and a hole is cut in the side of the ship, through which the repair is made. Hence it appears that there are limited access routes that could be used to transport relatively large objects between the decks of some ships. The US vessels to be discussed within this context are attack submarines (SSNs), frigates, cruisers, destroyers, battleships, ammunition ships, and aircraft carriers.

An SSN can carry up to approximately 30 weapons (torpedoes, conventional and nuclear Tomahawks, Harpoons or a mixture). Tomahawks can be fired from conventional torpedo tubes or from vertical launch systems (VLSs), which are to be installed at the bow between the inner and outer hulls of some attack submarines. The VLS will carry 12 Tomahawks; these weapons cannot be replaced or replenished from within the submarine. Random sampling of weapons in the VLS coupled with a thorough inspection of the torpedo room, where weapons are placed on racks, and of torpedo tubes, would be effective in preventing the deployment of illegal SLCMs among legal weapons. Experience with public inspections in port suggests that it should be possible to inspect a submarine, as described above, without revealing sensitive information.

When a Tomahawk is fired, it produces a large volume of high-pressure exhaust gas, which has to be vented in some way. For surface ships this is accomplished by firing such weapons from standard launchers, which are located on a ship's top deck. The present design of warships is such that a cruise missile like a Tomahawk cannot be fired from the lower decks. Frigates, cruisers, destroyers, and battleships have some common design features that limit Tomahawk placement within these vessels while still having access to a ship's top deck. For example, none of these vessels has elevators large enough to transport a Tomahawk from the lower decks to the top deck. Furthermore the spacing between decks is roughly 10 to 12 feet so that a Tomahawk stored horizontally cannot be rotated to a vertical position and then passed up to the top deck. There are vertical trunks that pass through decks with large enough openings (3.2×3.2 meters) that could be used to store Tomahawks vertically. Inspecting the few vertical trunks on a surface ship should be sufficient to deter the concealment of

missiles in such places.

Each frigate, destroyer, and cruiser has a few compartments that are large enough to store Tomahawks and have access to a ship's top deck, namely a helicopter hanger, a torpedo room, and a deck house. Complete inspection of the above storage compartments would be more than sufficient to deter violations. In fact random sampling among these compartments probably would suffice.

For US battleships, occasional inspections of deck houses (there are no torpedo rooms or helicopter hangers) and large access routes (vertical trunks) to the top deck should be sufficient to deter the concealment of missiles in such places.

Ammunition ships have the capability of storing large numbers of Tomahawks and transporting them from the lower decks to the top deck. Fortunately there are only a dozen or so such ships, and they are not currently fitted with standard launchers. In principle, an ammunition ship could replenish other ships with nuclear SLCMs; however, this can be performed at sea only under relatively calm conditions. In practice US Tomahawks are not currently transferred at sea. Nevertheless, it will probably be necessary to search ammunition ships more thoroughly than frigates, cruisers, destroyers, and battleships in order to deter the concealment of illegal SLCMs.

The space available in aircraft carriers (there are 15 in the US Navy) is voluminous and would allow also transport of Tomahawks from the lower decks to the top deck, but aircraft carriers are not equipped with standard launchers. Each ship has in excess of 4,000 compartments. Based upon experience with US Navy material inspections it would probably take 200 men one day to thoroughly search an aircraft carrier. However, because the number of compartments suitable for storing SLCMs is probably 200 or so, the inspection effort might turn out to be much easier. In principle, an aircraft carrier could replenish other ships with nuclear SLCMs; however, as in the case of ammunition ships, replenishment can be performed at sea only under relatively calm conditions. Because of their large volumes aircraft carriers require a more time-consuming inspection effort.

If the above inspection procedures were adopted there would be reasonable confidence that illegal SLCMs were not on board these vessels

during peacetime. Even if illegal SLCMs slipped through the inspection process, there are limitations on the transfer of such weapons from concealed storage compartments to standard launchers. The crane contained within the three launch tubes of a VLS is not currently used to load and unload Tomahawks, because these missiles along with their canisters exceed the weight limit of the crane. Tomahawks are currently loaded and unloaded in port. The armored-box launchers (ABLs) used to launch SLCMs from US battleships are high up in the ship's superstructure and there is no means on board to transport Tomahawks from the top deck to the box launcher. Therefore loading of weapons into ABLs also takes place in port via a crane. Hence, the emplacement of a large enough crane on board these ships would be an indication of the potential for violation.