THE NONPROLIFERATION AND DISARMAMENT CHALLENGES OF NAVAL NUCLEAR PROPULSION

A Quid Pro Quo for Nuclear-Armed States and NPT Non-Nuclear Weapon States

A proposal for the 2020 NPT Review Conference

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FAS Federation of American Scientists

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Cover Photo: Jets conduct a flyover during the aircraft carrier USS *Gerald R. Ford*'s (CVN 78) commissioning ceremony at Naval Station Norfolk, VA. Ford is the lead ship of the *Ford*-class aircraft carriers, and the first new U.S. aircraft carrier designed in 40 years.
(Photo by Andrew J Sneeringer/U.S. Navy. Caption via Wikimedia Commons.)

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This quid pro quo initiative addressing naval reactor programs couples a proliferation concern with a corresponding disarmament concern in a manner that will hopefully make the combination more attractive than a solution to either alone.

It comes at a time when the great majority of states have completed drafting the Treaty on the Prohibition of Nuclear Weapons (TPNW), which will be made available for states to sign at the United Nations on September 20, 2017. The TPNW is presently opposed by states possessing nuclear arms and many of their allies, setting the stage for a confrontation at the next review conference on the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). As parties to the NPT, China, France, Great Britain, Russia, and the United States – the officially recognized nuclear weapon states (NWS) – have sworn to pursue nuclear disarmament but have not made any significant headway. The NPT will be 50 years old in 2020, and while it has been extraordinarily successful at reining in proliferation, progress on disarmament is still waiting. The TPNW will be in force well before 2020; thus, the stakes are very high, risking the very future of the NPT.

Of the many issues affecting both proliferation and disarmament, naval reactors present a unique opportunity for the international community to find common ground, at least for now, and stave off a 2020 showdown. The proliferation and disarmament issues associated with naval reactors will need to be addressed at some point.

The proliferation concern is a so-called loophole that might allow a state that does not possess nuclear arms to take nuclear material outside of safeguards for use in naval reactors, and then potentially divert some of that material into weapons. The proposed solution (as described in this report) would take highly enriched uranium (HEU) off the table as a potential fuel for future nuclear-powered warships in non-nuclear weapon state (NNWS) parties to the NPT, clarify the transition points for the application of IAEA safeguards in those states, add targeted verification activities to limit the amounts of enriched uranium whose use would otherwise be unknown, and add transparency to assure that a state's naval reactor program is just that and nothing more.

The corresponding disarmament concern is that nuclear-armed states[1] could use their nuclear navies to justify setting aside large amounts of enriched uranium to meet their future reactor fuel requirements, raising the possibility that the stocks they set aside might be reprogrammed for nuclear weapons use. Any nuclear-armed state might produce enriched uranium in existing plants, or new ones. Any such state might provide HEU to states without nuclear weapons in conjunction with the sale or lease of nuclear-powered warships,

1 There are five states having nuclear weapons that are parties to the NPT (China, France, Russia, the UK and the US). These five are the permanent members of the UN Security Council, and are hence also known as the "P5". They are identified within the NPT as nuclear weapon states, or NWS, the counterpart of the 186 NPT states parties that don't have nuclear weapons. Outside the NPT, there are four more states that have nuclear weapons (India, Israel, North Korea and Pakistan). The term "nuclear-armed state" includes all nine.

possibly contributing to proliferation. The solution for these disarmament and proliferation concerns would be to transition away from HEU to LEU use, accept verification on supplies of HEU and LEU committed to naval reactor use, accept verification to limit the amounts of enriched uranium in the naval reactor fuel cycle whose use would otherwise be unknown, and adopt confidence-building measures aimed at providing assurance of the legitimacy of the declared naval reactor programs.

At present, no NNWS is on the verge of building nuclear-powered submarines or other nuclear-powered warships. While there is no driving urgency, it would be useful now to clarify the conditions under which such a program should be implemented when an NNWS decides to proceed. The United States and the United Kingdom use 93 percent enriched HEU, while Russia and India use enrichments of around 40 to 60 percent. France has already given up its earlier use of HEU in favor of LEU for its nuclear-powered attack submarines, ballistic missile submarines, and its aircraft carrier. The U.S. Navy is developing plans for phasing out of its use of HEU (if it is required to do so). China uses LEU fuels (according to unofficial sources, but the Chinese government usually does not comment on nuclear naval matters). And Brazil – still not certain whether it will or will not have a nuclear navy – has decided that if it does, it, too, will use only LEU fuels. Hence, all states with nuclear navies should follow France and China and phase out HEU usage for their naval reactors, and the future naval reactor programs of any NNWS should not allow the use of HEU.

The continued viability of the NPT regime will hinge on the actions taken by the P5 states and what they agree to in 2020.[2] Ideally, by 2020, the P5 could accept the TPNW, agree to finish the Fissile Material Cutoff Treaty (FMCT), bring the CTBT into force, and address the naval reactor issues described in this report. If the P5 are not able to accept these steps by 2020, then perhaps this modest naval reactor proposal might provide a way for them to postpone the more consequential disarmament decisions at least until 2025. This naval reactors proposal would not require the P5 to disarm, but it would require that they make a commitment relevant to disarmament nonetheless.

Recognizing that India now has a nuclear navy, intends to expand it, and is not a party to the NPT – thus not subject directly to the RevCon – this quid pro quo should apply to India and to any other nuclear-armed state that later decides it needs a nuclear navy.

The proposal addressing non-nuclear weapon states follows the mandatory process set forth in Paragraph 14 of the comprehensive IAEA safeguards agreement with the state, that the "arrangements" implementing Paragraph 14 would be agreed by the Agency and the state, and approved by the IAEA Board of Governors. This report presents steps to be taken if a state produces its own naval reactors and fuels, if it imports reactors, reactor fuels, or enriched uranium for naval reactor use from a supplier state. Nine specific recommenda-

2 Noting that the NPT obligations to work towards disarmament apply formally only to China, France, Russia, the United Kingdom and the United States, but that the global aspirations for a world without nuclear weapons applies to all states possessing nuclear arms, i.e., the five just noted, plus India, Israel, North Korea and Pakistan.

tions are put forward to achieve the non-proliferation objectives cited above.

The proposal affecting the nuclear-armed states addresses relevant objectives aimed at preventing proliferation, facilitating verification of enriched uranium in the naval reactor fuel cycle while respecting classification restrictions, and confidence-building measures to provide transparency and assurance of the legitimacy of a nuclear-armed state's naval reactor program. Specific steps are provided in nine additional recommendations. Noting that nuclear-armed states are not obligated to pursue any existing process, three alternative mechanisms might be adopted: a new standalone safeguards agreement limited to the use of enriched uranium in naval reactors; provisions that could be included in an FMCT; and, of course, corresponding provisions to be included in the obligatory verification requirements under the TPNW when the states with nuclear navies are ready to sign on.

INTRODUCTION

A so-called loophole might allow a non-nuclear weapon state (NNWS) to use a naval reactor program to acquire nuclear weapons by taking nuclear material outside of safeguards and then potentially diverting some of that material. Additionally, nuclear-armed states with nuclear-powered warships might use their naval reactor programs to justify keeping a substantial inventory of highly enriched uranium (HEU)[3] that could be quickly converted to nuclear weapon use or low enriched uranium (LEU) that could also be converted, but with more steps required to boost the LEU to HEU. Recognizing these and related nonproliferation and disarmament challenges, this report presents a proposal for the 2020 Non-Proliferation Treaty (NPT) Review Conference: a naval reactor quid pro quo (QPQ) for nuclear-armed states[4] and NPT non-nuclear weapon states.

If this QPQ is adopted, nuclear weapon states (NWS) and non-nuclear weapon states (NNWS) party to the NPT would agree to close the two potential loopholes by committing not to use HEU in any naval reactor they might pursue[5] by accepting targeted verification measures to limit the amounts of HEU or LEU available without scrutiny, and by adopting confidence-building measures to assure the international community that a naval reactor program is just that and nothing more. The disarmament commitments accepted by the P5 (the five Permanent Members of the UN Security Council, which are also the five NWS under the NPT) would extend by precedent to any other state having nuclear-powered warships, including India.

On the NWS side, action is needed on one or more significant steps toward nuclear disarmament, or else the 2020 NPT RevCon could fail to find consensus and that outcome could endanger the continued viability of the NPT regime. With this QPQ initiative, the five nuclear weapon states parties to the NPT, China, France, Great Britain, Russia, and the United States have three options to choose from:

1. Sign the Treaty for the Prohibition of Nuclear Weapons.[6]

2. Begin forthwith the negotiation of a fissile material cutoff treaty (FMCT) including provisions for existing stocks of weapon-usable fissile materials and naval reactors.[7]

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3 Following IAEA terminology, highly enriched uranium (HEU) contains 20% or more of the fissile isotope 235U; low enriched uranium (LEU) contains less than 20%.

4 Note that the term "nuclear weapon state" is used to identify states with nuclear weapons that are parties to the NPT. The term "nuclear-armed state" applies to any state possessing nuclear weapons, regardless of whether a state is or is not a party to the NPT.

5 Given that some nuclear-armed states have many nuclear-powered warships with proven designs and planned construction programs extending for decades, the transition from HEU to LEU will need to be agreed on a state-by-state basis, and additional targeted verification and confidence-building measures (CBMs) will be required during the respective transition periods.

6 A/CONF.229/2017/L.3/Rev.1, *Draft treaty on the prohibition of nuclear weapons*, http://www.undocs.org/en/a/conf.229/2017/L.3/Rev.1, accessed 11 July 2017.

7 Negotiations on an FMCT will have to decide on a host of issues, such as defining fissile material, production, and whether or not existing stocks of fissile material would be included

3. And/or, as a provisional step, conclude an IAEA safeguards agreement on the use of nuclear material in naval reactor programs.

2020 will mark the 50th anniversary of the entry into force of the Treaty on the Non-Proliferation of Nuclear Weapons (the NPT). With 191 parties, only the United Nations Charter is more widely accepted.[8] All NPT parties gather at the United Nations Headquarters every five years to review implementation of the NPT, and every review involves a struggle to produce a unanimously supported Final Agreed Statement. While it is not essential for the parties to produce a Final Agreed Statement, failure to agree on a Final Statement damages the NPT's stature and fosters frustration and disappointment. Having failed to produce a Final Agreed Statement at the 2015 Review Conference, the Review Conference coinciding with the 50th anniversary of the NPT in 2020 will carry very high expectations.

Perhaps the most contentious issue confronting the NPT is the lack of progress on the disarmament article of the Treaty:

> Article VI
>
> Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control.[9]

The anticipation of confrontation comes with 50 years of essentially no progress on disarmament, noting that the Comprehensive Nuclear Test Ban Treaty (CTBT) has yet to enter into force, and that negotiations on a fissile material cutoff treaty have yet to start (the Shannon Mandate[10] for negotiating an FMCT was agreed 22 years ago). Reflecting the reluctance of nuclear-armed states to consider disarmament, in December 2016 a United Nations General Assembly Resolution[11] was agreed upon, calling for "A Conference to negotiate a legally binding instrument to prohibit nuclear weapons, leading to their total elim-

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in the treaty. All are contentious; states possessing nuclear arms are likely to want to circumscribe its scope to future production.

8 United Nations Office for Disarmament Affairs, http://disarmament.un.org/treaties/t/npt, accessed 13 May 2017.

9 Text of the NPT. See: https://www.iaea.org/sites/default/files/publications/documents/infcircs/1970/infcirc140.pdf, accessed 13 May 2017.

10 See, for example, http://www.reachingcriticalwill.org/resources/fact-sheets/critical-issues/4737-fissile-material-cut-off-treaty, accessed 30 June 2017.

11 United Nations General Assembly (2016), Resolution adopted by the General Assembly on 23 December 2016 on taking forward multilateral nuclear disarmament negotiations, (A/RES/71/258). Note that while resolutions of the United Nations Security Council are subject to veto by any of the five permanent Security Council members (who happen to have nuclear navies and nuclear weapons), resolutions of the General Assembly cannot be vetoed.

ination."[12] The drafting is complete and the Treaty on the Prohibition of Nuclear Weapons (the TPNW) will be available for states to sign as from September 20, 2017.

It will be difficult for the 2020 RevCon to accept further delays or distractions (like the glossary of terms presented by the P5 to the 2015 NPT RevCon). Finding a way to accept the TPNW would be best; failing that, concluding an FMCT would be a useful step, though an FMCT would most likely distract and delay substantive progress on disarmament for a generation.[13] If neither of these steps can be agreed to, then the QPQ could at least be a useful step in the right direction, albeit less important than the TPNW or even the FMCT.

The QPQ alone might enable the P5 to at least hold the NPT together to get past 2020 without a disaster, postponing the real decisions on disarmament yet again to 2025. The QPQ comprises three elements:

1. A commitment not to use HEU to fuel any nuclear-powered warship, or if currently employing HEU for such purposes, a commitment to transition from HEU to LEU as soon as can be practically accomplished.[14]

2. Transition points where normal IAEA safeguards would allow naval reactor use, and resumption of safeguards at appropriate times, plus selective verification procedures to limit the amounts of HEU or LEU intended for use in naval reactors, but potentially available for use in nuclear weapons, and on which no information regarding their use would be available.

3. And confidence-building measures to provide assurance that a declared naval reactor program is bona fide.

The details of these provisions will vary depending on whether the QPQ is intended to address the NNWS loophole or NWS disarmament.

ADDRESSING THE SO-CALLED NON-PROLIFERATION LOOPHOLE

The NPT does not prohibit the 186 non-nuclear weapon states (NNWS) parties from having nuclear-powered warships. Italy and the Netherlands argued for this right during the drafting of Paragraph 14 of the model International Atomic Energy Agency comprehensive

12 A/CONF.229/2017/L.3/Rev.1, op.cit.

13 I estimate that it would take about five years to negotiate the FMCT, with the nuclear-armed states using every means to delay its completion; five years more for the states signing the FMCT to bring it into force, and ten years more to resolve all technical and procedural implementation steps that will arise – some legitimately, and others raised to delay progress. I believe that a separate FMCT is not needed, as the provisions that should be included in an FMCT could be included in the verification provisions that will be adopted for the TPNW.

14 France used HEU earlier, but decided it could meet all of its mission requirements at lower cost – including ballistic missile and attack submarines, and an aircraft carrier – with LEU. A. Tournyol du Clos (December 2016), *France's Choice for Naval Nuclear Propulsion: Why Low-Enriched Uranium was Chosen*, Special Report, Federation of American Scientists.

safeguards agreement for NNWS parties to the NPT.[15,16,17]

> NON-APPLICATION OF SAFEGUARDS TO NUCLEAR MATERIAL TO BE USED IN NON-PEACEFUL ACTIVITIES
>
> 14. The Agreement should provide that if the state intends to exercise its discretion to use nuclear material which is required to be safeguarded thereunder in a nuclear activity which does not require the application of safeguards under the Agreement,[18] the following procedures will apply:
>
> (a) The state shall inform the Agency of the activity, making it clear:
>
> (i) That the use of the nuclear material in a non-proscribed military activity will not be in conflict with an undertaking the state may have given and in respect of which Agency safeguards apply, that the nuclear material will be used only in a peaceful nuclear activity;[19] and
>
> (ii) That during the period of non-application of safeguards the nuclear material will not be used for the production of nuclear weapons or other nuclear explosive devices;
>
> (b) The Agency and the state shall make an arrangement so that, only while the nuclear material is in such an activity, the safeguards provided for in the Agreement will not be applied. The arrangement shall identify, to the extent possible, the period or circumstances during which safeguards will not be applied. In any event, the safeguards provided for in the Agreement shall again apply as soon as the nuclear material is reintroduced into a peaceful nuclear activity. The Agency shall be kept informed of the total quantity and compo-

15 J.C. Moltz (1998), "Closing the NPT Loophole on Exports of Naval Propulsion Reactors," *The Nonproliferation Review*, Fall 1998, p.106.

16 IAEA (1972), *The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, INFCIRC/153 (Corrected).

17 For a legal analysis of these provisions, see L. Rockwood (August 2017), *Naval Nuclear Propulsion and IAEA Safeguards*, Issue Brief, Federation of American Scientists.

18 Note that Paragraph 14 does not specify when the provisions of the safeguards Agreement might stop and start, nor does it prevent targeted safeguards activities outside of the existing safeguards Agreement to allow the IAEA to derive information on nuclear material committed to use in a naval reactor program, nor does it prevent the use of confidence-building measures to provide assurance against the possible use of naval reactors as a means to conceal a nuclear weapons program.

19 This provision would apply to nuclear material obtained by the state under a separate agreement in which the supplier includes an explicit restriction against the use of that nuclear material for any military purpose. For example, Canada and Australia include such restrictions on their uranium exports. This provision would not apply to indigenous uranium or uranium imported without such a restriction.

sition of such un-safeguarded nuclear material in the state and of any exports of such material; and

(c) Each arrangement shall be made in agreement with the Agency. The Agency's agreement shall be given as promptly as possible; it shall only relate to die temporal and procedural provisions, reporting arrangements, etc., but shall not involve any approval or classified knowledge of the military activity or relate to the use of the nuclear material therein.

While not explicitly stated, it is generally understood that naval reactors are included under Paragraph 14, as would reactors for other military applications (e.g. space).[20] Also, while the first sentence of Paragraph 14(b) above states that the safeguards provided in the safeguards agreement will not be applied, it offers no suggestions of alternative measures that might be applied to assure that a non-nuclear weapon state does not use a naval reactor program as a means to proliferate. For the Board of Governors to approve of the first such "Arrangements," they will need to be convinced that the provisions effectively prevent naval reactors from being a pathway to proliferation, and provide transparency to provide assurance that a naval reactor program is just that and nothing more, that it is not connected to nuclear weapons, and is not intended to further any other purpose.

Nuclear power provides a possible means to propel military and non-military ships. Russia currently has an extensive fleet of nuclear-powered icebreakers to provide access on its vast northern coast. No other state has any nuclear-powered ships except for warships. Germany (with the Otto Hahn) and Japan (with the Mutsu) explored the feasibility of nuclear-powered merchant vessels, but those programs were abandoned long ago. The United States once had a nuclear-powered merchant vessel (NS Savannah) that is no more. Given the importance of maritime access to the northern seas, additional states bordering the Arctic Ocean may pursue nuclear-powered icebreakers in the future.[21] Should another non-nuclear weapon state build a nuclear-powered icebreaker or other ship that is not a military vessel, the normal provisions of its safeguards agreement would apply, and the provisions of Paragraph 14 would not apply.

Canada approached the IAEA with the intention of acquiring nuclear-powered submarines, but abandoned its effort in 1990.[22] Brazil has had a nuclear submarine program underway

20 M.-F. Desjardins and T. Rauf (1988), *Opening Pandora's Box? Nuclear Powered Submarines and the Spread of Nuclear Weapons*, Aurora Papers 8, The Canadian Centre for Arms Control and Disarmament.

21 Admiral J. Stavridis, USN (Ret.) (2017), *Sea Power: The History and Geopolitics of the World's Oceans*, New York, Penguin Press.

22 M. Miller and T. Rauf (2003), CD/1719, included in a Letter dated 1 October 2003 from the Permanent Representative of the Netherlands to the Conference on Disarmament Addressed to the Secretary General of the Conference on Disarmament Transmitting a Summary of the Fifth Open-Ended Informal Meeting in the Framework of the Netherlands' FMCT Exercise, on a Treaty Banning the Production of Fissile Material for Nuclear Weapons and other Nuclear Explosive Devices, Held in Geneva on 26 September 2003.

since 1979, but Brazil has not yet engaged the IAEA on Article 13 of the safeguards agreement between the IAEA, Argentina, and Brazil (which corresponds to but differs slightly from Paragraph 14 of INFCIRC/153);[23,24] the success of the Brazilian naval reactor program remains uncertain.[25] Iran has mentioned an interest in naval reactors and nuclear-powered merchant vessels, but no programs have been put forward. Other states might also pursue naval reactor programs, notably Argentina, Australia, Japan, Pakistan, and South Korea.

As Brazil has discovered, naval reactors are technically complex, costly, and require a dedicated program consuming significant tax revenues for decades. And as France discovered, using HEU may be too expensive and the benefits of long core life may conflict with safety access restrictions established under national law.[26] And while nuclear-powered naval warships remain attractive, recent advances in non-nuclear technologies like large-storage capacity chemical batteries and air-independent propulsion systems mean that non-nuclear submarines can provide many of their benefits.[27,28]

In sum, closing the potential NNWS loophole now would be opportune, without the political pressures that will likely arise when a concrete proposal is put forward. Including a prohibition on the use of HEU use in future naval reactors will reduce the risks of both proliferation and nuclear terrorism.[29]

PROPOSED ARRANGEMENTS FOR NNWS

Through the NPT Review Process, the NPT parties should recommend that the IAEA develop and approve "model arrangements" as appropriate to meet the requirements of INFCIRC/153 Paragraph 14.[30] To facilitate this step, the 2020 RevCon may wish to include the recommendations set forth below in the Final Agreed Statement of the 2020 NPT RevCon, or in a separate document if the RevCon is unable to reach a Final Agreed Statement in 2020. The Arrangements that the IAEA and a state accept should become part of the state's

23 IAEA (1994), Agreement of 13 December 1991 between The Republic of Argentina, the Federative Republic of Brazil, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials and the International Atomic Energy Agency for the Application of Safeguards, https://www.iaea.org/sites/default/files/infcirc435.pdf, accessed 25 May 2017.

24 L. Rockwood, op.cit.

25 M. Spektor, *Prospects for Safeguarding Brazil's Naval Nuclear Propulsion Program*, Issue Brief, Federation of American Scientists (August 2017).

26 Tournyol du Clos, op.cit.

27 See, for example, https://www.treehugger.com/clean-technology/welcome-era-giant-batteries-ge-build-its-largest-grid-scale-battery-date.html, accessed 14 May 2017.

28 A video tutorial on AIP can be found at: https://www.youtube.com/watch?v=tze6zgrRJKM, accessed 1 July 2017.

29 The gun-type nuclear explosive device—the basis of the Hiroshima bomb—uses HEU and would likely be able to be built by technically sophisticated terrorist groups. See, for example, C. D. Ferguson and W. C. Potter et al., *The Four Faces of Nuclear Terrorism* (Routledge, 2015).

30 A 2014 article provides a number of similar recommendations. See: S. Philippe (2014), "Safeguarding the Military Naval Fuel Cycle," *Journal of Nuclear Materials Management*, Spring 2014 Volume XLII, No. 3, p.40 et.seq.

comprehensive IAEA safeguards Agreement, and as such, be ratified by the state following its constitutional procedures and approved by the IAEA Board of Governors.

Consistent with the purpose and provisions of the NPT, an NNWS electing to pursue nuclear-powered warships should conduct its activities with full transparency to avoid suspicion:

> **Recommendation #1:** An NNWS seeking to develop and build nuclear-powered naval vessels should have an Additional Protocol in force.[31]

> **Recommendation #2:** Mindful of the inalienable rights of non-nuclear weapon states parties to the NPT to peaceful uses of nuclear energy, no NNWS should argue a need for naval reactors as a basis for justifying the acquisition of uranium enrichment technology.

Noting the global effort to eliminate, to the extent possible, all uses of HEU, and the French findings,[32] any proposal by an NNWS "requiring" HEU for the purposes of fueling naval warships should be viewed with suspicion:[33]

> **Recommendation #3:** An NNWS should use only LEU to fuel any naval reactor.

The provisions of Paragraph 14 need to be considered in relation to the need to assure that nuclear material committed to naval reactor use is not used to support a nuclear weapons program, while respecting legitimate military secrets deemed by the state to warrant restricted access.

> **Recommendation #4:** The total amount of uranium and the enrichment level of uranium used in naval reactor fuel should not be classified, should be declared by the state, and should be verified by the IAEA.

All nuclear material in an NNWS is subject to IAEA safeguards pursuant to Article III of the NPT and Paragraph 1 of the safeguards Agreement. The manner and extent to which IAEA safeguards techniques can and should be applied in relation to Paragraph 14 will depend

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31 Following the discovery of nuclear weapons programs in Iraq and North Korea, the IAEA extended its safeguards system through an "Additional Protocol" to safeguards agreements, providing greater access to information, personnel, and locations, as a means to detect undeclared nuclear material or activities that could be used to build nuclear weapons. Each state concludes an Additional Protocol as an extension to its safeguards Agreement, and as such, the AP must be ratified through the state's constitutional practices and approved by the IAEA Board of Governors. The Model Additional Protocol is published in INFCIRC/540, https://www.iaea.org/sites/default/files/infcirc540.pdf, accessed 15 July 2017.

32 Tournyol du Clos, op.cit.

33 See, for example, *Communication dated 30 January 2017 received from the Permanent Mission of Norway concerning a Joint Statement on Minimizing and Eliminating the Use of Highly Enriched Uranium in Civilian Applications*, https://www.iaea.org/sites/default/files/publications/documents/infcircs/2017/infcirc912.pdf, accessed 14 May 2017.

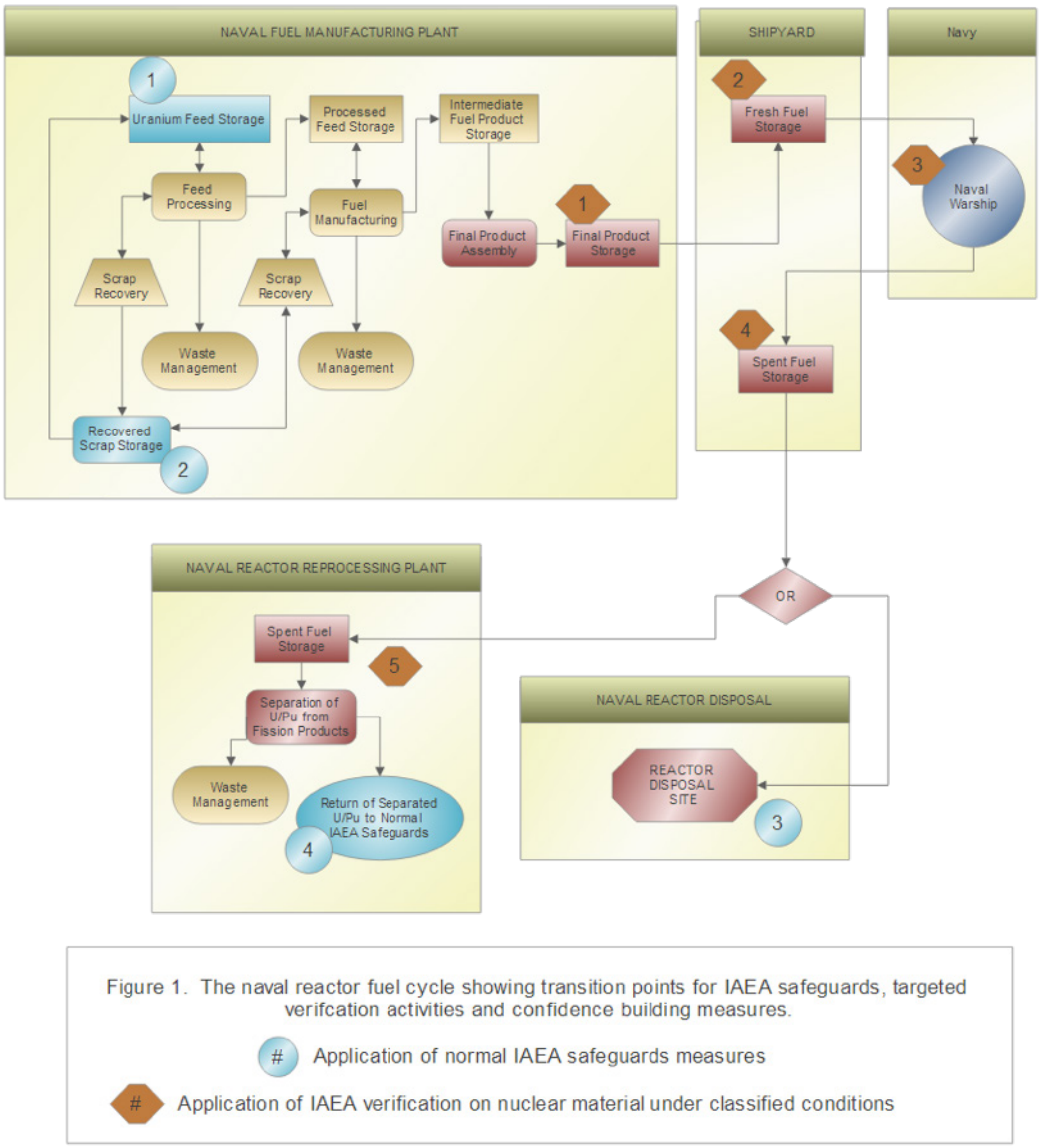

Figure 1

on how an NNWS will acquire and maintain its nuclear-powered warships. In principle, an NNWS might purchase or lease complete nuclear-powered warships from an existing supplier, or purchase or lease nuclear reactors with fuel for warships that the NNWS builds or otherwise obtains. Or the NNWS may decide to develop and build its own naval reactors to install in warships it purchases, leases, or builds itself.

Two naval reactor program options are considered:

CASE A: AN NNWS MANUFACTURES ITS OWN NAVAL REACTOR FUEL

The state and the IAEA should consult on how safeguards should be applied in relation to the naval reactor fuel cycle adopted by an NNWS, taking into account the state's requests for restrictions to protect its national security. A full naval reactor fuel cycle is shown above in Figure 1, which assumes that the shape, dimensions, and construction methods of naval reactor fuel elements and/or the full reactor core would be classified. Figure 1 is intended

to serve as a starting point on where and how the Agency could verify and limit the amounts of nuclear material that it could confirm to be present within the naval reactor complex, and where and how the IAEA could apply confidence-building measures to assure that an NNWS naval reactor program is being implemented as declared.

The first block in Figure 1 is the fuel manufacturing stage, where pure compounds of enriched uranium (e.g. UF6, UO2, or uranium nitrate (UNH) crystals) are delivered to the plant and stored until needed. The first manufacturing step is to convert the uranium from the chemical form received into the form needed to produce the fuel. Next comes the fuel manufacturing itself, producing intermediate products depending on the design of the reactor (e.g. fuel plates or fuel pellets and rods). Next comes the final product (e.g. fuel elements or integral reactor cores). All nuclear reactor fuel manufacturing operations generate radioactive waste that is sent for disposal and process scrap materials, which, in most cases, can be recycled into the production operation (e.g. by dry oxidation/reduction methods or by dissolution and ion exchange purification processes).

The finished fuel elements or integral cores are shipped to a location (perhaps a shipyard) where they will be stored until they can be installed in a designated warship.

Spent fuel elements or integral cores may also be removed from the warship at the end of their service life at this same location, pending their direct disposal or reprocessing.

The warship then carries out its military missions using the nuclear reactor(s) on board. Some naval reactors are refueled periodically, while some – especially U.S. Navy reactors – are designed for extended operations, ideally, to operate on a single fuel charge for the life of the vessel.

Spent fuel that will not be reprocessed will be stored indefinitely until the state's capabilities for emplacement in a repository are completed.

Spent fuel that will be reprocessed will be sent to a suitable facility for dissolution and separation of the unused uranium and any plutonium produced during the operation of the reactor from the high-level radioactive waste.[34]

It is reasonable to anticipate that every state would protect its military secrets, including access aboard its warships and information on its naval reactors including their geometry, dimensions, control mechanisms, and propulsion mechanics. While respecting these wishes, the IAEA and the state will need to agree on the verification procedures, including the possible use of managed access as provided in the Additional Protocol.

> **Recommendation #5:** IAEA safeguards should be applied throughout the reactor and reactor fuel manufacturing processes except as restricted by the state for legitimate

34 Note that the uranium in spent fuel from reactors burning very highly enriched uranium (e.g., 93%) will likely still be above 20% enrichment and hence still be treated by the IAEA as HEU.

military secrecy considerations.

IAEA inspections should begin with the presumption that normal safeguards practices apply and then introduce restrictions as necessary to accommodate the provisions of Paragraph 14 to protect information classified by the state. Such limitations may make it impossible for the IAEA to apply nuclear materials accountancy[35] as the basis for its conclusions. To minimize the amounts of nuclear material which could be available to the state, should it decide to pursue nuclear weapons, the IAEA should verify periodically as much as possible of the inventory of nuclear material within each fuel cycle facility. The IAEA must honor the state's classification restrictions but verify as accurately as the methods available and the restrictions imposed allow, including the uranium content and enrichment level of fuel elements or integral cores, and intermediate products in internal stores within the fuel manufacturing operations. The IAEA must implement additional confidence-building measures to provide assurance of the legitimacy of the state's naval reactor program.

All fuel cycle facilities should be declared to the IAEA following normal practices when the state notifies the IAEA of its intention to implement Paragraph 14. The state should provide design information questionnaires (DIQs) for those facilities taking into account how classification restrictions will be reflected in the information provided in the DIQ, how design information verification will be carried out, and how classification restrictions will affect the safeguards approach for all naval reactor fuel cycle facilities, including inspector access, and Agency inspection equipment selection and use. Following normal practice, draft and/or incomplete DIQs should be provided early on and be completed following consultations with the IAEA. Safeguards implementation matters, including material balance areas and key measurement points, material description codes, provisions for operating and accounting records, and reports to the Agency should, to the extent possible, follow normal IAEA safeguards practice according to the Safeguards Agreement in force, including the General Part of the Subsidiary Arrangements and Facility Attachments relevant to that Safeguards Agreement.

Recommendation #6: IAEA safeguards verification procedures should be applied to all portions of the fuel manufacturing operations not restricted by classification.

Recommendation #7: Fuel materials within the process area, and accumulated scrap should be processed to permit periodic verification such that as much as possible of the nuclear material residing in a naval reactor fuel cycle plant can be inspected at least once per year.

35 Nuclear materials accountancy involves closing a material balance at annual intervals and determining if the amount of material-unaccounted-for (MUF) is consistent with legitimate measurement uncertainties. MUF should be zero over a defined material balance period (e.g., one year). If not zero, the value should lie within the limit of error for the measurements made to determine each of the components of the MUF equation:

MUF = Beginning Inventory + Receipts − Shipments − Ending Inventory

Recommendation #8: The total uranium and the 235U content of finished reactor cores, fuel elements, fuel rods or other fuel forms should be verified using applicable IAEA safeguards non-destructive methods. As may be necessary to protect classification of fuel design shapes and dimensions, verification should be carried out under managed-access provisions of the Additional Protocol.

Recommendation #9: Verification discrepancies and anomalies on individual items, batches, material balance components, or on the value of material unaccounted for (MUF) should be investigated and resolved forthwith.

The principal confidence-building measure is to carry out inspector visits to each nuclear-powered vessel shortly after its reactor is started initially, and following each refueling, to confirm that the vessel is, in fact, nuclear-powered. Additional inspector visits would be scheduled when a reactor core is one-third through its life cycle and again at two-thirds.

Two alternative methods may be chosen:

Method 1: IAEA inspectors might use a portable neutron detector at a location adjacent to or onboard a nuclear-powered vessel at a location where an Agency inspector is able to detect leakage neutrons from each reactor on each warship. The vessel commander would adjust the reactor power as requested by the Agency inspector.[36] This method is used routinely to verify the presence of core fuel in research reactors under IAEA safeguards. Note that the vessel should be isolated from other neutron sources (notably, nuclear submarines are often tied up to piers side by side). If a vessel contains more than one reactor, appropriate steps should be taken to confirm that each reactor is adjusting its power according to the inspector's instructions.

Method 2: Metal tabs of titanium or hafnium (for example) could be installed adjacent to each reactor vessel in an accessible location aboard each nuclear-powered warship in a containment enclosure maintained under IAEA seals. At periodic intervals, and at each refueling, an Agency inspector would replace the tabs and return the irradiated tabs to Agency Headquarters for analysis. When analyzed, the tabs will demonstrate that the reactor had produced significant amounts of power.

Depending on how a ship is configured, once the IAEA has confirmed that the nuclear reactor is functioning, it may be possible to apply IAEA seals to hatches that would have to be opened to allow access to the reactor. The IAEA and the state would come to an agreement on how the needs of transparency could be met.

36 IAEA (2011), *Safeguards Techniques and Equipment: 2011 Edition*, International Nuclear Verification Series No. 1 (Rev. 2), p.19. "A hand-held neutron monitor comprises 3He proportional neutron counters, a Geiger-Müller counter and integrated electronics that provide a means of localizing neutron radiation sources."

CASE B: AN NNWS IMPORTS FRESH NAVAL REACTOR FUEL AND/OR EXPORTS SPENT FUEL

An NNWS might conceivably support its naval warships by securing fresh fuel supplies and/or spent fuel services from another state. It should be assumed that the supplier would not suborn proliferation by its customer, and that the supplier would be prepared to submit reports to the IAEA in relation to the services provided. The specific arrangements should be described in the Paragraph 14 arrangements, which would be accepted by the NNWS acquiring naval reactor fuel supplies and services, and by the supplier state. The verification and confidence-building measures applied in the NNWS might then be decreased from those suggested for Case A.

The verification requirements appropriate for these circumstances can also be seen in reference to Figure 1.

Option B.1: Fresh fuel is received into the NNWS and is loaded into a naval reactor by the NNWS. The NNWS will make provisions for the IAEA to verify the fresh fuel on the territory of the NNWS using standard IAEA inspection equipment if the fresh fuel is not classified or by use of managed access provisions otherwise. Such verification activities could be carried out at a separate storage facility, or in the shipyard where fuel loading is provided.

Option B.2: Fresh fuel is installed in the reactor by the supplier state on board the NNWS naval vessel (the initial core and reloads, as applicable) either on the territory of the supplier or on the territory of the NNWS. No verification should be required if the supplier state agrees to report to the Agency on each fueling operation. If not, then the provisions of B.1 would apply.

Option B.3: Spent fuel is left in the NNWS to be disposed of or reprocessed. The CBMs identified for Case A above would be applied. IAEA verification would commence when the spent fuel is removed from the vessel and would be maintained using appropriate methods into direct disposal or through reprocessing, as relevant. If the supplier state claims that the spent fuel is classified, then appropriate managed access arrangements will be agreed and implemented.

Option B.4: Spent fuel is returned to the supplier state. Two circumstances are envisioned:

a. If the spent fuel is discharged from the vessel on the territory of the NNWS, stored for some time, then packaged and shipped back to the supplier state, the provisions of B.1 apply during the time that the spent fuel remains in the NNWS. When returned to the supplier state, the supplier agrees to report its return to the IAEA and the NNWS accounts are closed accordingly.

b. If the spent fuel is removed from the vessel on the territory of the supplier state, under its control, the supplier state reports the completion of the discharge of the spent fuel from the vessel to the IAEA and the NNWS accounts are closed accordingly.

In addition to these verification requirements, the same confidence-building measures identified for Case A should be applied to Case B.

The combination of staying clear of HEU, of specifying the stopping and starting points for the IAEA safeguards agreement to apply, the introduction of selective verification activities within a naval reactor fuel cycle, and the use of confidence-building measures to provide proof that a naval warship declared as being nuclear-powered is just that. This constitutes the "quid" in quid pro quo (QPQ) – now for the "quo."

QPQ ARRANGEMENTS FOR STATES WITH NUCLEAR NAVIES

Six nations now have nuclear navies.[37] These six – China France, India, Russia, the United Kingdom, and the United States – also possess nuclear weapons. Their nuclear-powered submarines are able to cruise submerged farther and faster than conventionally powered submarines, and their silent running features help prevent their detection. Nuclear-powered naval warships offer enhanced range, the ability to generate greater amounts of power for speed and weapon systems support, and greater independence from supply sources. Nuclear-powered submarines can produce all the oxygen and potable water they need, hence only the food supplies they can stow on board and crew tolerance limit how long they can remain submerged.

Five of these six states are NWS parties to the NPT and hence have sworn to honor all of its Articles, especially Articles I, III, and VI. India is not a party to the NPT and hence is not explicitly subject to its provisions. Of the six, the United States and the United Kingdom use HEU enriched to approximately 93 percent. Russia and India use HEU of about 40 percent enrichment, while France and China (according to unofficial sources) use LEU fuels. Some of the following recommendations should apply equally to all six states, while others should apply first to the United States and United Kingdom, then Russia and India, and finally to China and France. Should Russia, India, China, or France already use higher enrichment uranium fuels for their nuclear-powered warships or elect to use higher enrichments in the future, then they would move up in priority, accordingly.

While NNWS parties to the NPT have in place a required process to follow should they wish to acquire naval reactors, no existing treaties limit the nuclear-armed states' naval reactor programs. Their naval reactor programs will hinder progress under the TPNW and under an FMCT (if it is decided that a separate FMCT has merit). They could also facilitate proliferation if appropriate controls are not applied to assistance programs with NNWS. Naval reactor programs must be included in the scope of disarmament, especially for those states employing HEU fuels. Nuclear-armed states might pursue one of three alternative implementation arrangements:

37 For a listing of all nuclear-powered ships, past and present, see: http://www.radiationworks.com/nuclearships.htm, accessed 16 May 2017.

a. Sign the TPNW and work out arrangements under that Treaty to address the issues below related to preventing proliferation and facilitating nuclear disarmament. Noting that the NPT will be 50 years old in 2020, and that no consequential decisions have been taken on how to even approach disarmament, an ambitious undertaking to develop, negotiate and join a comprehensive nuclear disarmament framework is urgently needed including mechanisms for eliminating existing arsenals and for preventing rearmament, including provisions for naval reactor programs.[38,39]

b. Negotiate, sign and bring into force a fissile material cutoff treaty that includes provisions for naval reactors.[40] The Shannon Mandate on the outlines of what an FMCT might include is now 22 years old, yet an FMCT is no closer today than it was then.[41]

c. Conclude a new type of IAEA safeguards agreement tailored to the use of nuclear material in naval reactors, which could apply equally to any state having a naval reactor program, regardless of whether or not it is a party to the NPT. A draft Naval Use Safeguards Agreement (NUSA) could be developed that could allow any of the six states to accept controls on its practices and verification and confidence-building measures to provide transparency and assurance that its nuclear navies do not create either horizontal or vertical proliferation problems.[42]

For the P5, signing the TPNW would be the most meaningful step they could take to meet their Article VI obligations under the NPT, and thereby help to secure the future viability of the NPT. I believe it would take decades to safely eliminate all existing nuclear weapons, and to put in place verification arrangements that would prevent rearmament. Making the initial commitments now, and helping to craft the nuclear disarmament regime to follow, is the right step for the P5 to take, and for all remaining nuclear-armed states to follow their lead.

However, if the Treaty on the Prohibition of Nuclear Weapons (the TPNW) is not acceptable to the five nuclear weapon states (NWS) parties to the Treaty on the Non-Proliferation of Nuclear Weapons (the NPT) by the time of the 2020 NPT Review Conference (RevCon),

38 TPNW, op.cit.

39 T. Shea and L. Rockwood (2018), *Verifying The Treaty on The Prohibition of Nuclear Weapons*, Routledge Press, London, (Current working title, to be published).

40 T. Shea (2003), "The Fissile Material Cut-Off Treaty: A Venue for Future Progress in Arms Control, Nonproliferation, and the Prevention of Nuclear Terrorism," *Journal of Nuclear Materials Management*, Fall 2003, Volume XXXII, No. 1, p.34, et.seq

41 Report of Ambassador Gerald E. Shannon of Canada on Consultations on the Most Appropriate Arrangement to Negotiate a Treaty Banning the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices, CD/1299, 24 March 1995. See: https://fas.org/programs/ssp/nukes/armscontrol/shannon.html, accessed 25 May 2017

42 As discussed in detail in N. Egel, B. L. Goldblum, and E. Suzuki, "A Novel Framework for Safeguarding Naval Nuclear Material," *Nonproliferation Review* (June 2015), and as expanded in A. Reddie et al., submitted summer 2017 for peer review to be published.

perhaps postponing a decision on the TPNW until 2025 and agreeing by the time of the 2020 RevCon to sign a fissile material cutoff treaty (an FMCT) could be enough to avert a disastrous confrontation, especially if all P5 states included an agreement to sign and ratify the Comprehensive Nuclear Test Ban Treaty. That could at least avert the worst outcome for the NPT RevCon.

If neither of these is doable, then the QPQ might be implemented alone through a NUSA, which might take on greater importance. Preferably, the naval reactor issues would need to be incorporated in the verification framework for the TPNW, or in the FMCT. Choosing NUSA as a sop for 2020 may be enough – or not.

All NPT states could call upon the NWS in the 2020 Final Agreement and, by extension, India and the remaining non-NPT nuclear-armed states (Israel, North Korea, and Pakistan) to undertake certain obligations that would help to stop proliferation and nuclear terrorism. All nuclear-armed states should be prepared to accept policies and practices that will enhance the prospects for nuclear disarmament and strengthen the non-proliferation regime. In relation to naval reactors and other programs, they should agree to phase out the use of HEU, accept verification and monitoring of their fresh fuel stocks, and agree to phase in confidence-building measures and selective verification tied to progress in disarmament. As disarmament succeeds, the risks of rearmament and the means through which nuclear-armed states could secure functional – if not optimal – nuclear weapons will make their naval reactor programs increasingly important.

The recommendations below have three objectives:

a. Keep naval reactor programs from facilitating proliferation.

b. Assure that any stocks of HEU (and eventually LEU) set aside for naval reactor use are not diverted to nuclear weapons use.

c. Provide confidence in the legitimacy of each naval reactor program.

OBJECTIVE A: INHIBITING PROLIFERATION

Consistent with the global effort to eliminate HEU, each nuclear-armed state should agree not to encourage or assist any state seeking to use HEU for any purpose, including fuel for naval reactors.[43]

Recommendation #10: No state should supply enrichment technology to an NNWS to enable such a state to enrich uranium allegedly for a naval reactor program.

43 Notwithstanding the importance of introducing nuclear-powered warships on regional military stability, I am not aware of any restrictions affecting the sale or lease of nuclear-powered warships from a supplier to another state. Indeed, cooperation between Russia and India has benefited both states.

Recommendation #11: No nuclear-armed state should assist any other state to acquire nuclear-powered naval vessels using HEU fuel. As applicable, each nuclear-armed state should transition from its own use of HEU in naval reactors to LEU. Such a move would reduce the possibility that terrorists might acquire HEU, or that nuclear-armed states might have a need to reopen an HEU enrichment plant or to build a new one.

Recommendation #12: No state possessing nuclear-powered warships currently using LEU should shift to using HEU fuel.

Recommendation #13: All nuclear-armed states employing HEU fuel should transition to LEU fuel as soon as practicable.[44,45]

Recommendation #14: A state having stocks of HEU in excess of its naval reactor needs should down-blend its surplus HEU to LEU levels.

OBJECTIVE B: PREVENTING DIVERSION OF HEU (AND EVENTUALLY LEU) FROM NAVAL REACTORS TO NUCLEAR WEAPONS

Recommendation #15: The United States and Great Britain should place their inventories of LEU feed stocks under IAEA safeguards under an appropriate agreement to be concluded between the state and the IAEA as soon as possible. As this step is completed, Russia and India should place their HEU feed stocks under IAEA safeguards under an appropriate agreement to be concluded between the state and the IAEA. As this step is completed, China and France should place their HEU feed stocks under IAEA safeguards under an appropriate agreement to be concluded between the state and the IAEA.

Recommendation #16: When the conditions of Recommendation #15 have been met, the IAEA and the state shall agree on procedures for the state to inventory all remaining feed stocks, intermediate product and final product (fuel elements or integral reactor cores) at each naval reactor fuel manufacturing plant, making use of managed access arrangements in those cases where the state classifies the properties of its naval reactor fuels. The IAEA should verify each new or reload integral reactor core or fuel elements to verify that the enrichment level, the total amount of uranium and the total amount of 235U contained are as declared. Once verified, the IAEA should apply containment and surveillance measures to assure that the reactor core/fuel is actually loaded aboard the declared vessel, and that as soon as possible

44 France has already transitioned from HEU to LEU naval reactor fuels. Tournyol du Clos, op.cit.

45 The U.S. Navy is considering the feasibility of transitioning from HEU to LEU fuels and anticipates formidable performance requirements and significant cost penalties affecting such a transition. National Nuclear Security Administration (2016), *Conceptual Research and Development Plan for Low-Enriched Uranium Naval Fuel*, Report to Congress, July 2016. See: http://fissilematerials.org/library/doe16.pdf, accessed 17 May 2017.

thereafter, the IAEA should verify that each nuclear reactor on board each nuclear-powered warship is operational.

Recommendation #17: When the conditions for Recommendation #15 have been met, the IAEA and the state shall agree on the verification of all spent fuel discharged from nuclear-powered warships, especially spent fuel containing HEU. Thereafter, the IAEA will verify the spent fuel and its disposition.

OBJECTIVE C: CONFIDENCE-BUILDING MEASURES

Recommendation #18: The IAEA should employ seals on the access hatches to each reactor on each nuclear-powered warship, and/or neutron fluence tabs to ensure that the naval reactors remain as declared, installed, and in use. The timing and mechanisms for the IAEA to verify the installed seals and fluence tabs should depend on the expected core lifetime of the reactors and the time from the installation of the seals and tabs.

WHY THE QPQ SHOULD SUCCEED

All nuclear-armed states need to find constructive steps to begin the search for disarmament. Continuing to wave off the states interested in a secure peace will put at risk the integrity of the NPT and undermine the pursuit of a world free of nuclear weapons.

Firstly, the naval reactor impacts on nonproliferation and disarmament addressed in this report are real, important, but not particularly pressing. That means that the 2020 NPT RevCon could provide a chance to help complete the nonproliferation regime and a chance to have the P5 take a modest step toward meeting their overdue disarmament-related obligations.

Closing the loophole that NNWS might pursue will strengthen the NPT regime and make it clear that this is not a pathway to nuclear weapons. It is both prudent and opportunistic to close this possible shortcoming now, in conjunction with the 50th anniversary of the NPT in 2020. Interested parties might examine the recommendations set out in this report before the 2020 RevCon begins, perhaps through the auspices of the Vienna Centre for Disarmament and Non-Proliferation and the forthcoming PrepCom in Geneva in 2018, such that going into the RevCon, an amended body of recommendations could present a broad consensus of the international community.

Most NNWS have no interest in acquiring nuclear-powered warships; in fact, some have opted to exclude Paragraph 14 from their IAEA safeguards Agreements. The NNWS should support the further clarification of nonproliferation policies in relation to the use of nuclear material in naval reactor programs. They should welcome the opportunity to decide on the IAEA inspection activities and confidence-building measures that would apply in the future when one of them decides to acquire nuclear-powered warships. When the NNWS agree to refine and support IAEA verification and confidence-building measures for NNWS adoption of nuclear-powered warships, the NNWS will be better able to press the NWS, and nuclear-armed states outside the NPT, towards progress on disarmament in general, including

the issue of how to address their nuclear-powered naval warships.

Secondly, after 50 years of hand-waving, the NPT NWS should start the process of disarmament by buying into the TPNW, the FMCT (if its provisions cannot be accommodated within the TPNW), and the CTBT. The NPT NWS should address the naval reactor concerns noted, and if agreement on the TPNW is not possible, then the P5 should go with the naval reactor proposal put forward in this report as a starter, and vow to make the greater commitments by 2025.

Depending on how the P5 choose to address the TPNW at the 50th anniversary of the NPT, with the vows they have taken in accepting Article VI or desperate attempts to revive an unnecessary separate FMCT and the urgency of bringing the CTBT into force, the need to turn to the naval reactor programs of nuclear-armed states might provide a last best chance.

Naval reactor programs could provide possible sources of HEU for weapons if a nuclear-armed state should decide to rearm, or justify continued operation of existing (or new) HEU enrichment plants. Naval reactor programs in nuclear-armed states would complicate accountancy on HEU and LEU in relation to disarmament, and delay progress toward the ultimate aim of eliminating all existing nuclear weapons and preventing new ones from being built.

Continued use of HEU in naval reactors provides just another means to continue to justify the need for HEU, which serves against the global initiatives to eliminate all uses of HEU, given its ease of use in nuclear weapons. Responsible states should act in a responsible manner.

This proposal comes from my 47-year career in nonproliferation and nuclear disarmament, especially the 25 years I worked in the IAEA safeguards department, developing the safeguards system, finding practical solutions to safeguarding facilities producing, processing and using plutonium and highly enriched uranium, and leading the Trilateral Initiative,[46] the IAEA FMCT working group, and an IAEA internal CTBT analysis. I believe that all of the rec-

46 The Trilateral Initiative was a six-year project involving the Russian Federation, the United States and the IAEA. Its objective was to develop the technical and legal foundations that would enable the IAEA to verify classified forms of weapon-origin fissile material. The Trilateral Initiative was endorsed in the 2000 NPT Final Statement as point #8 of the 13 points adopted in relation to Article VI, endorsed during a 3.5-hour discussion in the IAEA Board of Governors, and concluded in 2002 following changes in the Governments of the Russian Federation and the United States. Both the United States and Russia considered the Trilateral Initiative to have been successful and commitments were made to continue work towards implementation. Un fortunately, no such steps have been taken. T. Shea and L. Rockwood (2015), *Nuclear Disarmament: The Legacy of the Trilateral Initiative*, Deep Cuts Working Paper No. 4, http://deepcuts.org/images/PDF/DeepCuts_WP4_Shea_Rockwood_UK.pdf, accessed 13 July 2017.

ommendations included in this report could be adopted now and could be made to work.

At the age of 18, I went to sea as a crewman in an attack squadron (VA-65) aboard the USS Intrepid, and later, on the first operational cruise of the USS Enterprise, CVA(N)-65, America's first nuclear-powered aircraft carrier.

I do not believe that any of the proposals put forward in this report would impede the ability of any nuclear-powered naval warships to carry out their intended missions. The proposals are made recognizing that future peace and security will require all activities that might bear upon the production of nuclear weapons come under international scrutiny, as an essential step towards maintaining the cohesion of the international commitments against proliferation and terrorism, and as essential steps towards a world in which nuclear-armed states may find ways to move away from relying on their nuclear arsenals and eventually towards nuclear disarmament.

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