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Threat Assessment Brief
Analysis on Effective Policy Responses to Weapons-Related Security Threats

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The Naval Nuclear Reactor Threat to the NPT

The nuclear Nonproliferation Treaty (NPT) has long been a critical bulwark against the spread of nuclear weapons. Although preventing the production and accumulation of fissile material is an important part of this effort, the NPT does not explicitly regulate the production, use, and disposition of highly enriched uranium (HEU) for naval nuclear reactors. This exclusion poses a growing risk to achieving the nonproliferation goals of the treaty. While seeking to advance prospects for a fissile material cutoff treaty, the United States is continuing to design naval reactors for the world's largest nuclear submarine fleet that are powered with weapons-grade uranium. While proclaiming its renunciation of any nuclear weapons ambitions, Brazil plans to build six nuclear submarines powered by uranium fuel that may be close to weapons grade. Neither the International Atomic Energy Agency (IAEA) nor important NPT member states have fully confronted the proliferation implications of excluding naval reactor fuel from safeguards. The IAEA and NPT members should take steps to minimize the use of HEU for any reason—a goal they declared just this month at a nuclear security conference in Vienna.

HIGHLIGHTS

- Because acquiring fissile material is the biggest technical obstacle to building nuclear weapons, discouraging uranium enrichment above levels used in civilian power reactors is an important barrier to proliferation.
- But the NPT allows states to use uranium enriched to higher levels to fuel naval propulsion reactors, free from the IAEA safeguards that would otherwise apply.
- This exclusion confers legitimacy on enriching uranium beyond the level needed for civilian power reactors and could potentially be exploited by aspiring nuclear-weapon states to provide a shield for diversion of that material for use in a nuclear weapons program.
- Brazil, poised to become the first NPT non-nuclear-weapon state with nuclear-powered submarines, could create a dangerous precedent for states seeking to enrich uranium to weapons-grade or near-weapons-grade levels.
- Iran is a case in point. With six world powers trying to negotiate limits on the size and enrichment level of Iranian uranium hexafluoride stockpiles, senior Iranian naval officers say they are considering their own nuclear submarines, using fuel enriched to "45-56 percent."
- Meanwhile, as Russia and France dramatically reduce the enrichment levels required by their newer submarine reactors, the United States and United Kingdom are still designing reactors for the next half-century that require weapons-grade uranium.
- The U.S. Defense and Energy Departments should urgently consider options for building future U.S. submarine reactors fueled by uranium that is not highly enriched.
- The IAEA should seek enhancements to safeguards agreements that tighten monitoring measures for uranium designated for naval nuclear reactors.

A Brief Overview of Naval Nuclear Propulsion

Incorporating nuclear propulsion in submarines has been one of the most revolutionary advances in undersea weaponry. The nuclear reactor increases a submarine's performance by allowing it to surface less frequently and operate at higher speed and for longer periods of time without refueling. Given the high cost of nuclear propulsion technology and the difficulty of obtaining reactor fuel, for many years only the five nuclear-weapon states party to the nuclear Nonproliferation Treaty (NPT) had developed and deployed their own nuclear-powered submarines. Over the past decade, however, other states have shown interest in developing such vessels (see table 1).

The proliferation of nuclear propulsion technology has ignited new proliferation concerns for several reasons. Most existing submarines use the same grade of enriched uranium (>90 percent) needed for nuclear weapons. Four of the seven countries operating or planning to operate nuclear-powered submarines are using or will use some level of highly enriched uranium (HEU)—that is, uranium with an enrichment level of at least 20 percent U-235—in their reactors. A fifth country, Brazil, may intend to enrich close to 20 percent, putting it much closer to the level of enrichment needed for nuclear explosives than it would be with only the 3.5 percent enriched uranium typically used in civilian power reactors.

Second, as with all nuclear reactors, submarine reactors produce a plutonium isotope (Pu-239) as a byproduct, which can then be extracted for use in weapons. The reactors also produce tritium, a radioactive isotope of hydrogen that is rarely found in nature and is an essential part of the triggering mechanism used in thermonuclear weapons.

Initially, only nuclear-weapon states had developed nuclear propulsion capabilities. Because these countries already were creating significant amounts of fissile material for weapons that were free from monitoring by the International Atomic Energy Agency (IAEA), their use of weapons-grade uranium in naval reactors seemed far removed from either the disarmament or nonproliferation concerns of the NPT.

Moreover, when the NPT was first being negotiated, many non-nuclear-weapon states were reluctant to give up their right to use nuclear propulsion reactors for commercial shipping. They therefore negotiated with the nuclear-weapon states an inclusion of nuclear propulsion activities within the category of acceptable uses for enriching uranium.[1] Consequently, the text of the NPT does not regulate the use of fissile material for nuclear propulsion activities and focuses exclusively on its use in nuclear weapons and other explosive devices. Notwithstanding the original intent to protect commercial use options, this provision has been used almost exclusively to facilitate use of nuclear propulsion technologies for military purposes.

Table 1: Nuclear-Powered Submarines

COUNTRY	NUMBER OPERATIONAL*	FUEL ENRICHMENT (%U-235)
United States	72	97
Russia	46	20-45
United Kingdom	12	97
France	10	7.5
China	10	5
India	2	40

*These numbers include some submarines, which are in service, but not yet or no longer fully mission-capable.

Brazil plans to build six nuclear-powered submarines, fueled by low enriched uranium (<20 percent). Other countries expressing an interest in leasing or building nuclear-powered submarines include Argentina, Iran, Pakistan, and Venezuela.

Source: Arms Control Association

Differential Treatment

Under the terms of the NPT, enriched uranium that is burned in naval propulsion reactors is not subject to safeguards in either nuclear-weapon states (NWS) or non-nuclear-weapon states (NNWS). However, there are some important differences under the treaty between the kind of safeguards agreements the two categories of states negotiate.

Although the NPT does not require nuclear-weapon state members to negotiate safeguards agreements with the IAEA, all five have signed "reduced" versions in order to boost the adoption of safeguards agreements among non-nuclear-weapon states. When the first safeguards agreements were being drafted, several industrialized non-nuclear-weapon states worried that such agreements would hinder their nuclear industry capabilities by putting an additional economic burden on them, and leave untouched the nuclear industries of the nuclear-weapon states.[2] Therefore, in order to encourage the signing of such agreements, the United States negotiated a safeguards agreement with the IAEA in 1978 (Information Circular 288 or INFCIRC/288)[3] and ratified it in 1980. The IAEA reached similar agreements with the other nuclear-weapon states—the United Kingdom in 1978 (INFCIRC/263), France in 1981 (INFCIRC/290), the Soviet Union in 1985

(INFCIRC/327), and China in 1989 (INFCIRC/369).[4] However, these safeguards do not apply to all of the enriched uranium being produced, only to that at some civilian nuclear facilities.

The application of safeguards for non-nuclear weapon states is quite different. According to Article III (1) of the NPT, "[e]ach non-nuclear-weapon State Party to the Treaty undertakes to accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency...for the exclusive purpose of verification of the fulfillment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices." Consequently, most non-nuclear-weapon states negotiated and ratified comprehensive safeguards agreements with the IAEA.[5] Safeguards are applied to all nuclear material used for civilian purposes. Therefore, given that it is not lawful for non-nuclear-weapon states to have nuclear weapons programs, safeguards are implemented on 100 percent of their nuclear material.

The comprehensive safeguards agreements mandated by the NPT regulate the use of nuclear material for naval propulsion only minimally. The model safeguards agreement for NNWS parties to the NPT is provided in IAEA INFCIRC/153. Paragraph 14 of this circular allows the nuclear material of states parties not to be subject to safeguards if it is destined for non-proscribed military activities. But additional provisions in the paragraph suggest that the IAEA was aware of potential hazards in this exclusion. If a state intends to exercise its right to use nuclear material in such an activity—for example, for nuclear submarine propulsion—the safeguards agreement requires three elements:

- First, 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; and

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The HMS Vigilant, shown off the coast of Scotland in 2012, is one of four UK Vanguard-class SSBNs, whose nuclear propulsion reactors run on weapons-grade uranium. The Royal Navy is planning to replace these submarines with the Successor-class, powered by a new reactor, starting around 2028. U.S. Ohio-class SSBNs also use weapons-grade uranium fuel and are scheduled to be replaced with the SSBN(X), starting in 2029.

(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.[6]

- Second, the IAEA 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."[7] The objective of this arrangement is to identify the period or circumstances during which safeguards will not be applied. Additionally, the parties are required to agree on a reapplication of safeguards to the nuclear material that has been withdrawn from safeguards and used as prescribed "as soon as the nuclear material is reintroduced into a peaceful nuclear activity."[8] In addition, the IAEA must be kept informed of "the total quantity and composition of such unsafeguarded nuclear material in the State and of any exports of such material."[9]

- Third, although INFCIRC/153 states that "each arrangement shall be made in agreement with the Agency," it also specifies that such arrangements "shall only relate to the 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."[10]

In spite of these requirements, it is logical to conclude that the minimal legal framework and the absence of any precedent for establishing additional transparency standards would make it very difficult for the IAEA to achieve a timely detection of any nuclear weapons-related use of fissile material designated for naval nuclear propulsion.

The Case of Brazil

Brazil's naval nuclear reactor program has its origins in Brazil's nuclear weapons program, started under the 1964-85 military dictatorship. There were then three separate and parallel nuclear technology programs, pursued by each of Brazil's three military services. The navy's program survived the shutdown of nuclear weapons efforts in the late 1980s and evolved into the technology generator and non-nuclear-weapons-related military program of today.

Although there had been some question as to whether Brazil would follow through on its long-standing aspirations to acquire nuclear-powered submarines, policy declarations of two consecutive administrations, budgetary commitments, and an extensive construction program constitute convincing evidence that the nuclear submarine program is now well established (see table 2). According to the Brazilian navy, Brazil needs the program "in order to fulfill its constitutional mission of defending the sovereignty, territorial integrity, and maritime interests of the country."[11]

The development of Brazil's nuclear-powered submarine is now part of a joint venture with France, initiated in 2008. France will provide Brazil with the technology required to build one nuclear-powered and four diesel-electric submarines in the first stage; Brazil intends ultimately to construct six nuclear and 20 conventional submarines. However, both France and Brazil have clearly stated that that the nuclear technology for the nuclear-powered submarine reactor will be developed indigenously by Brazil. Paris is supposed to transfer technology for the construction of the conventional submarines and for the non-nuclear components of Brazil's nuclear-powered submarine.[12] The Brazilian navy has stated that a land-based prototype submarine reactor is in development and is scheduled to be completed by 2014.

Brazil's choice of France for assistance with future submarine construction at first seems surprising given Brazil's previous close cooperative relationship with

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Table 2: Brazilian Nuclear Developments

Brazil currently has two operating nuclear power reactors (Angra 1 and 2) and a third (Angra 3) under construction. The Nuclear Fuel Factory in Resende, state of Rio de Janeiro, enriches uranium and produces fuel rods for these reactors. A new multipurpose research reactor and a prototype submarine reactor are under construction at Iperó, state of São Paulo.

EVENT	DATE	NOTES
Brazil signs Treaty of Tlatelolco.	1967	Prohibits manufacture, acquisition, possession, testing, or use of nuclear weapons in Latin America and the Caribbean.
Brazilian Constitution is passed.	1988	Article 21, XXIII (a) bans nuclear weapons development.
Brazil signs Quadripartite Agreement, along with Argentina, the International Atomic Energy Agency (IAEA), and the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials.	1991	Provides for joint development of nuclear energy for peaceful purposes. (The agreement entered into force in 1994.)
Brazil ratifies the Comprehensive Test Ban Treaty (CTBT) and the nuclear Nonproliferation Treaty (NPT).	1998	The CTBT prohibits all nuclear explosions, whether for military or for peaceful purposes. The NPT prohibits non-nuclear-weapon states from developing, acquiring, or transferring nuclear weapons and requires these states to accept IAEA safeguards over peaceful nuclear activities.
Brazil's president announces plans to build a nuclear-powered submarine.	2007	President pledges 130 million reals ($81.8 million) per year to fund the project.
Brazil and France establish military partnership.	2008	The agreement, worth 8.6 billion euros ($12 billion) includes technology transfer and purchase of 50 helicopters, one nuclear submarine, and four conventional submarines.
Brazil and Argentina agree to build two nuclear research reactors, one in each country.	2011	The new Brazilian multipurpose research reactor in Iperó, São Paulo will be responsible for testing Brazil's nuclear fuel. It is scheduled to begin operations in 2017.
First nuclear submarine due to be completed.	2023	The submarine is scheduled to become operational in 2025.
Last of planned nuclear submarines due to be completed.	2047	This will complete the full complement of Brazilian submarines, six nuclear and 20 conventional.

—Research conducted by Victor Silva

Germany in acquiring and constructing the five IKL-209 class submarines currently in Brazil's fleet. Switching technology suppliers inevitably wastes some of the substantial investments made in connecting with Germany's renowned conventional submarine design and construction operations. Germany, however, does not build nuclear-powered submarines. France, on the other hand, has extensive experience fitting nuclear reactors into submarine hulls and with all aspects of nuclear submarine operations.

Brazil is the first non-nuclear-weapon-state party to the NPT to initiate a nuclear-powered submarine program. The case is therefore particularly important, and problematic, in terms of establishing a new rationale for NNWS to enrich uranium beyond the 3.5 percent level needed for civilian power reactors. Although Brazil already possesses the uranium-enrichment technology that is needed for producing civilian power reactor fuel, it is unclear whether or not Brazil intends to use uranium enriched to a level near HEU, which would give it a uranium stockpile that has undergone most of the enrichment work needed to become suitable for use in weapons.

A Dangerous Precedent?

In 1991 Brazil and Argentina signed the Guadalajara Agreement according to which they bound themselves to the exclusively peaceful use of nuclear energy and created the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) to oversee the application and management of the Common System for Accounting and Control of Nuclear Materials. This "Quadripartite Agreement" (INFCIRC/435), which was signed after the creation of ABACC, represents the legal instrument that regulates the relationship among Brazil, Argentina, ABACC and the IAEA, and defines the cooperative activities for the joint application of nuclear safeguards.

Considering Brazil's constitutional commitment to the exclusive use of nuclear energy for peaceful purposes[13] and its many multilateral nonproliferation commitments (NPT, Quadripartite Agreement, ABACC, Treaty of Tlatelolco, Nuclear Suppliers Group, and Comprehensive

Vanderlei Almeida/AFP/Getty Images

A 2004 view of Brazi's nuclear enrichment plant at the Resende Nuclear Fuel Factory.

Test Ban Treaty), some would argue that Brazil has been setting a positive example in recent years for non-nuclear-weapon states that want to use nuclear energy for peaceful purposes.

However, Iran last year demonstrated how Brazil's nuclear submarine program precedent could be exploited by a NPT non-nuclear-weapon state seeking to justify the accumulation of HEU. Iran's deputy navy commander, Abbas Zamini, was quoted in June 2012 as saying that "preliminary steps in making an [Iranian] atomic submarine have started."[14] In April 2013, Fereydoun Abbasi, head of the Iranian Atomic Energy Organization, elaborated on the naval reactor option by saying that "[a]t present, we have no enrichment plan for purity levels above 20 percent, but when it comes to certain needs, for example, for some ships and submarines, if our researchers need to have a stronger underwater presence, we will have to make small engines which should be fueled by 45 to 56 percent enriched uranium."[15]

These statements caused alarm among the six (P5+1) powers negotiating with Iran to resolve concerns about the nature of its nuclear program. Iran appeared to be signaling that naval nuclear propulsion needs could provide cover for enriching uranium at levels even above the 20 percent used by the "Tehran Research Reactor." Thus, in conjunction with Brazil's continuing opposition to signing an additional protocol to its safeguards agreement with the IAEA,[16] its development of nuclear-powered submarines further complicates efforts to strengthen the international nuclear safeguards regime.

There is still controversy over whether the Brazilian nuclear submarine program creates an exploitable precedent. From a purely legal perspective, Brazil represents a sui generis case. The Quadripartite Agreement seems to leave open the possibility for Brazil to withdraw nuclear material for propulsion purposes. Specifically, Article 13 of that agreement allows a member state to "exercise its discretion to use nuclear material which is required to be safeguarded under this Agreement for nuclear propulsion or operation of any vehicle, including submarines and prototypes, or in such other non-proscribed nuclear activity."

However, Brazil's safeguards agreement is somewhat different from and potentially more restrictive than the model used for other non-nuclear-weapon states. First, while paragraph 1 of INFCIRC/153 refers to safeguards that should apply "in all peaceful activities,"[17] Article 1 of Brazil's agreement (INFCIRC/435) refers to safeguards that apply to "all nuclear material in all nuclear activities."[18] This leads to an interpretation that the safeguards exemption contained in paragraph 14 of INFCIRC/153 would not apply to Brazil. Secondly, Article 13 of Brazil's agreement does not specifically refer to the withdrawal of nuclear material, as contained in paragraph 14 of INFCIRC/153, but refers to the application of unspecified "special procedures" that are to apply if Brazil decides to use nuclear material for nuclear propulsion purposes.[19]

The case of Brazil demonstrates how non-nuclear-weapon states could use naval nuclear reactor fuel as justification for unmonitored accumulation of fissile material. Brazil's pursuit of nuclear submarines makes it easier for other states to use a similar justification for enriching uranium to levels of 20 percent or higher. At the same time, the particulars of INFCIR/435 suggest at least a chance that vigorous IAEA application of safeguards could create a precedent for monitoring such uses more closely.

Use of Weapons-Grade Uranium

On the other side of the divide between nuclear-weapon states and non-nuclear-weapon states, U.S. and U.K. dependence on weapons-grade uranium for their naval nuclear reactors into the indefinite future opens them up to charges of hypocrisy in their efforts to end the worldwide production of fissile material and to shrink global fissile material stockpiles.

Both NWS and NNWS categories of states should carefully consider the implications of their foreign ministers' unanimous declaration at the just-concluded International Conference on Nuclear Security in Vienna, where all 125 states in attendance, including the United States and the United Kingdom, agreed to: "[e]ncourage States to further minimize the use of high enriched uranium on a voluntary basis and to use low enriched uranium where technically and economically feasible."[20]

Recommendations

The United States and Brazil should both recognize that steps intended to enhance military security, such as building nuclear-powered submarines, can also do damage to national security if they hobble international efforts to curb proliferation.

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The United States and the United Kingdom are both getting ready to replace their current ballistic missile submarines with new hulls and components. Washington and London should urgently take nonproliferation goals into consideration before they lock in new reactor designs for the next half-century. France and Russia have built reactors using much lower levels of enriched uranium without requiring major sacrifices in performance. Yet neither the U.S. Navy nor the Department of Energy has shown any willingness to seriously study alternatives in planning the enormously expensive SSBN(X) program. Congress should require them to do so.

Brazil would do itself and the rest of the world a favor by abandoning the nuclear part of its ambitious submarine program. Such a step would not jeopardize Brazil's security or prosperity, given the enormous cost of nuclear submarines, the lack of a priority Brazilian mission for which such globe-spanning weapons platforms are optimized, and the impressive defense capabilities that Brazil will derive from the 20 modern conventional submarines it is planning to build in parallel with its nuclear submarine fleet. It is difficult to avoid the suspicion that Brazil's nuclear submarine quest is driven more by the pursuit of prestige than national security necessity.

Whether or not Brazil continues its pursuit of the nuclear submarine grail, the IAEA should take action to tighten up the legal framework for monitoring naval nuclear reactor programs in non-nuclear-weapon states. Safeguards arrangements negotiated with the IAEA should contain a detailed list of characteristics of the nuclear material to be withdrawn for submarine reactor fuel. The arrangements should address when the nuclear material contained in the spent fuel remaining as a byproduct of the submarine reactor's operations should be placed back under safeguards. The arrangements should allow the IAEA to acquire at least a minimum level of information regarding the use of the fuel for the duration of the military activities the fuel supports.

Conclusions

Naval nuclear reactor programs have heretofore been designed to maximize submarine performance, not to minimize negative impacts on nonproliferation regimes. This does not mean, however, that nonproliferation goals should be considered irrelevant, for any incentives to enrich uranium beyond the level needed for civilian power reactors encumber efforts to reduce nuclear dangers.

The weapons-grade uranium needed in U.S. submarine reactors are being supplied by excess inventories from its retired nuclear weapons stockpiles. Nonetheless, follow-on reactor designs are on track to give a fresh impetus to HEU use stretching far into the future. This fact weakens U.S. efforts to shrink worldwide production and possession of fissile material.

For non-nuclear-weapon states such as Brazil, the nuclear submarine program creates a military requirement for producing and stockpiling uranium enriched to a higher level than needed in civilian power reactors. The Brazilian precedent makes it easier for other states that may have nuclear weapons ambitions to use the NPT exclusion for nuclear submarine reactor fuel as cover for the pursuit of nuclear weapons.

There is no easy way around the naval nuclear reactor threat to the NPT, but it is time for NPT members and the IAEA to consider strategies for mitigation.

ENDNOTES

1. James Clay Moltz, "Closing the NPT Loophole on Exports of Naval Propulsion Reactors," *The Nonproliferation Review*, Fall 1998, p. 108.

2. A.von Baeckmann, *IAEA Safeguards in Nuclear-Weapon States. A Review of Objectives, Purposes, and Achievements*, IAEA Bulletin, 1998, p. 22.

3. Ibid.

4. For the texts of the agreements, see http://www.iaea.org/safeguards/framework.html. (The agreements that France and the United Kingdom reached were trilateral because both countries signed and ratified their safeguards agreements with both the IAEA and Euratom.)

5. Benin, Cape Verde, Djibouti, East Timor, and Guinea have signed a comprehensive safeguards agreement that has yet to enter into force; Equatorial Guinea has an agreement that has been approved by the Board of Governors but has yet to be signed; and Eritrea, Liberia, Micronesia, Sao Tomé and Principe, and Somalia have not yet submitted comprehensive safeguards agreements to the IAEA Board of Governors, "NPT Comprehensive Safeguards Agreements: Overview of Status," June 25, 2013.

6. INFCIRC/153, paragraph 14.

7. Ibid.

8. Ibid.

9. Ibid.

10. Ibid.

11. Official website of the Brazilian Navy, n.d., http://www.mar.mil.br/menu_v/ccsm/temas_relevantes/submarino_Escorpene.html.

12. Ibid.

13. According to Article 21 of Brazil's 1988 Federal Constitution: "All nuclear activity within the national territory shall only be admitted for peaceful purposes and subject to approval by the National Congress."

14. Zahra Hosseinian, "Iran Plans Nuclear-Powered Submarine: Report," Reuters, June 12, 2012.

15. Zachary Keck, "Iran's Nuclear Submarine Gambit," *The Diplomat*, April 18, 2013.

16. The "Additional Protocol" is a legal document, approved by the IAEA Board of Governors in 1997, granting the IAEA complementary inspection authority to that provided in underlying safeguards agreements. It has been signed by 141 states.

17. INFCIRC/153, paragraph 1.

18. INFCIRC/435, Article 1.

19. Ibid., Article 13.

20. Ministerial Declaration, "International Conference on Nuclear Security: Enhancing Global Efforts," Vienna, Austria, July 2, 2013, paragraph 12.