6 October 2021

To: President Joe Biden, The White House

Cc: Jake Sullivan, National Security Advisor
Anthony Blinken, Secretary of State
Lloyd Austin, Secretary of Defense
Carlos del Toro, Secretary of the Navy
Jill Hruby, Administrator, National Nuclear Security Administration (NNSA)

From: Robert L. Gallucci, Distinguished Professor, Georgetown Univ.; Former Ambassador at Large and Assistant Secretary of State for Political-Military Affairs
Daryl G. Kimball, Executive Director, Arms Control Association
Alan J. Kuperman, Assoc. Professor, LBJ School of Public Affairs; Coordinator, Nuclear Proliferation Prevention Project, Univ. of Texas at Austin; former Congressional staff
George M. Moore, Scientist-in-Residence, Middlebury Inst. of International Studies at Monterey
Thomas Shea, former senior researcher, IAEA Safeguards Division and Head, Defense Nuclear Non-Proliferation Programs, Pacific Northwest National Laboratory
Sharon Squassoni, Research Professor, Elliott School of International Affairs, George Washington University; former nonproliferation specialist with US State Department
Frank von Hippel, Professor of Public and International Affairs emeritus, Princeton University; former Assistant Director for National Security, White House Office of Science and Technology Policy *to whom correspondence should be addressed: fvhippel@princeton.edu*

Mitigate the proliferation impact of offering submarines fueled with weapon-grade-uranium to a non-nuclear-weapon state by committing to design future US naval reactors to use low-enriched-uranium fuel

We, the undersigned nonproliferation experts and former US government officials, are concerned that the AUKUS deal to supply Australia with nuclear-powered attack submarines fueled with weapon-grade uranium could have serious negative impacts on the global nuclear nonproliferation regime and thereby on US national security. These negative impacts could be mitigated by a serious US commitment to design future nuclear submarines to be fueled with non-weapon-usable low-enriched uranium (LEU), which contains less than 20% chain-reacting U-235. By contrast, highly enriched uranium (HEU) contains 20% or more U-235 and is considered weapon usable, while weapon-grade uranium contains more than 90% and is optimized for weapons use.

Impact of AUKUS on the nonproliferation regime. We are not concerned that Australia might extract HEU from the submarine fuel to make nuclear weapons.

Our concern is that providing Australia with HEU-fueled naval reactors could allow other states to invoke the AUKUS example to justify their own production or acquisition of HEU fuel.

This is not a theoretical concern. Iran is currently producing 60% enriched uranium that could be used directly without further enrichment to produce nuclear weapons.[1] At the UN, in late September 2021, aides to Iran's new foreign minister "noted that highly enriched uranium could be used in naval reactors, suggesting they might want to use it for that purpose. And they cited

Mr. Biden's new deal with Australia, which calls for the U.S. and Britain to supply Australia with the technology for nuclear-propelled submarines, which use highly enriched uranium."[2]

Some U.S. allies may ask for the same deal as Australia. South Korea could renew its request for help in acquiring nuclear attack submarines, which the Trump Administration rejected.[3] Leading Japanese politicians have recently expressed a similar interest.[4]

Countries also could respond by producing HEU themselves or seeking HEU-fueled reactors from Russia, which has exported HEU-fueled nuclear submarine technology to India. Russia has offered to share LEU-fueled reactor technology with South Korea for civilian maritime use[5] but could be emboldened by the US example to offer HEU-fueled designs.

HEU in naval-reactor fuel cycles in non-weapon states would create a monitoring nightmare for the International Atomic Energy Agency.[6] The IAEA is charged by the Treaty on the Nonproliferation of Nuclear Weapons with verifying that nuclear material in non-weapon states is not diverted to nuclear weapons. The IAEA is constrained, however, by Section 14 of its standard safeguard agreement, "Non-Application of Safeguards to Nuclear Material to be Used in [Non-Explosive] Non-Peaceful Activities,"[7] which would allow a country to exempt HEU fuel from normal inspections for decades. This well-known loophole has not yet been tested.

The challenge of verifying that submarine fuel is not diverted for nuclear weapons would be significantly easier if the fuel were made with LEU. Specifically, if a country has a uranium enrichment plant – as Brazil has for its nuclear submarine program – the IAEA can monitor the enrichment plant to assure that LEU is not being further enriched to HEU.[8] By contrast, HEU fuel could be diverted directly to a nuclear weapon without further enrichment.

France and China already use LEU fuel in their naval propulsion reactors. Offering such LEU-fueled reactors for the Australian submarines would avoid setting a dangerous precedent for non-weapon states.

The US and UK should commit to develop LEU fueled naval reactors. The US and UK should commit that any future exported naval-reactor technology will be LEU-fueled. To facilitate that and to provide a better model, the US and UK should conduct the research necessary to design their own future naval reactors to be fueled with LEU.

Such leadership has worked in the past. After the Carter Administration's 1977 decision to reduce proliferation risks by ending US civilian spent fuel reprocessing, the US was able to say to other states, "We don't separate plutonium from civilian fuel. You don't need to either." Today, only one non-nuclear-weapon state, Japan, still has a reprocessing program. Limiting naval fuel enrichment to LEU could have a similar exemplary global effect. The US deploys the world's largest fleets of both power and naval reactors.

The United States has been considering transitioning of US naval propulsion to LEU fuel since 1995. In 2016, in response to a request from Congress, NNSA provided a *Conceptual Research and Development Plan for Low-Enriched Uranium Naval Fuel*. The plan proposed using an advanced high-uranium-density fuel, which is already under development, to facilitate the transition. In his cover letter, NNSA's Deputy Administrator for Naval Reactors stated, "While success is not assured, this development has the potential to deliver a fuel that might enable an aircraft carrier reactor fueled with LEU in the 2040's."[9]

The elite JASON group of technical national-security consultants endorsed the proposed program.[10] The Obama White House also expressed its support.[11] In 2018, however, the Trump Administration rejected the plan.[12]

During the period 2016-2021, Congress has funded a modest LEU fuel development program for naval reactors – most recently through NNSA's Office of Defense Nuclear Nonproliferation, due to loss of interest within the office of Naval Reactors (NR). Unfortunately, the NNSA budget request for FY2022 did not include funding for this program.

It is not too late to mandate that NR itself develop LEU core designs and make clear that the Biden Administration intends to strengthen, not undermine, the longstanding US nonproliferation commitment to minimize HEU at home as well as abroad.

The first focus of the program should be to assure that the future *SSN(X)*, the replacement for the *Virginia*-class attack submarines, whose design has barely begun,[13] can accommodate an LEU core. As the 2016 JASON group review stated,

> If the reactor compartment is not designed to accommodate a life-of-ship LEU core, and if later re-design to accommodate such an LEU core is impractical, then HEU cores will be required for all [SSN(X)s], the last of which will launch in the 2060s. On the other hand, if design parameters and fuel development allow an LEU reactor … then it is possible that the Navy's final HEU core will be built in the 2040s.

A more compact life-of-the-ship LEU core, made possible using the high-density uranium fuel that NR currently has under development, would be desirable. If, however, as recently reported, the diameter of the *SSN(X)* is to be meters larger than that of the *Virginia*-class,[14] a larger life-of-the ship LEU core could be accommodated – even one based on current naval fuel density. As stated in a 1995 report to Congress from the Office of Naval Reactors, a one-meter increase in the diameter of the *Virginia* submarine hull (from 10 to 11 meters) would allow it to accommodate a lifetime LEU core without a change in fuel design.[15] A future replacement for the larger *Columbia*-class ballistic missile submarines could easily accommodate an LEU core.

A transition to LEU-fueled naval reactors in the 2040s also would make it possible to avoid the international opprobrium and cost that the US would incur if it resumed production of weapon-grade uranium for the first time since the end of the Cold War. DOE has projected that the excess US Cold War HEU that has thus far been committed for naval reactors should last into the 2050s or 2060s.[16] In 2015, DOE estimated a new enrichment plant would cost $6-11 billion.[17]

Recently, Representative William Foster of Illinois, the only PhD physicist in Congress, submitted an amendment to the National Defense Authorization Act for FY 2022 that would have required the NNSA Administrator to

> establish a program to assess the viability of using [LEU] in naval nuclear propulsion reactors . . . [and] submit to the congressional defense committees a report assessing the feasibility and performance impact of [a SSN(X) that] . . . leaves sufficient space for a [LEU] fueled reactor with a life of the ship core… [18]

We urge the Biden Administration to – at the very least – initiate an effort along those lines.

---

[1] Surrounded by a 5-cm beryllium neutron reflector, the critical mass of 60%-enriched would be about twice that of 93%-enriched HEU with a reflector of the same thickness, Alexander Glaser, "On the Proliferation Potential of

Uranium Fuel for Research Reactors at Various Enrichment Levels," *Science and Global Security* 14 (2006) https://scienceandglobalsecurity.org/archive/2006/05/on_the_proliferation_potential.html.

[2] David Sanger, Michael Crowley and Rick Gladstone, "Rebuking Biden, Iran's Chief Diplomat Demands More Sanctions Relief," *New York Times,* 24 Sept. 2021, https://www.nytimes.com/2021/09/24/world/middleeast/iran-nuclear-sanctions-biden.html.

[3] Mike Yeo, "Nuclear-Powered Subs, JSTARS Make South Korea's Wish List." *Defense News*, 8 November 2017, https://www.defensenews.com/global/asia-pacific/2017/11/08/nuclear-powered-subs-jstars-make-south-koreas-wish-list/.

[4] Steven Stashwick, "Japan's Kono Says He Supports Building Nuclear Submarines," *The Diplomat*, 28 September 2021, https://thediplomat.com/2021/09/japans-kono-says-he-supports-building-nuclear-submarines/.

[5] "Russia May Help South Korea to Build Nuclear Reactor for Maritime Vessels," (Sputnik News, 8 July 2018) https://sputniknews.com/20180807/russia-south-korea-nuclear-reactor-1067008274.html; *Solutions for the Shipbuilding Industry* (Atomenergomash JSC, 2020) https://aem-group.ru/static/images/buklety/2020/Booklet_sudostroenie_en.pdf.

[6] Francois Murphy, "AUKUS submarine deal 'very tricky' for nuclear inspectors -IAEA chief," Reuters, 28 Sept. 2021, https://www.reuters.com/world/aukus-submarine-deal-very-tricky-nuclear-inspectors-iaea-chief-2021-09-28/.

[7] Laura Rockwood, *Naval Nuclear Propulsion and IAEA Safeguards* (Federation of American Scientists, 2017) https://uploads.fas.org/media/Naval-Nuclear-Propulsion-and-IAEA-Safeguards.pdf. (Until 2013, Rockwood was Section Head for Non-Proliferation and Policy Making in the IAEA's Office of Legal Affairs.)

[8] Thomas E. Shea, *The Nonproliferation and Disarmament Challenges of Naval Nuclear Propulsion: A Quid Pro Quo for Nuclear-Armed States and NPT Non-Nuclear Weapon States* (Federation of American Scientists, 2017) https://uploads.fas.org/media/The-Nonproliferation-and-Disarmament-Challenges-of-Naval-Nuclear-Propulsion.pdf.

[9] *Conceptual Research and Development Plan for Low-Enriched Uranium Naval Fuel* (NNSA, 2016) https://fissilematerials.org/library/doe16.pdf.

[10] JASON Group, *Low-Enriched Uranium for Potential Naval Nuclear Propulsion Applications*, https://irp.fas.org/agency/dod/jason/leu-naval.pdf.

[11] "Feasibility of Low Enriched Uranium Fuel in Naval Reactor Plants" (White House, 31 March 2016) https://obamawhitehouse.archives.gov/the-press-office/2016/03/31/fact-sheet-feasibility-low-enriched-uranium-fuel-naval-reactor-plants.

[12] Secretary of the Navy Spencer and Secretary of Energy Perry, letter to Senator Deb Fischer, Chairman, Subcommittee on Strategic Forces, Committee on Armed Services, U.S. Senate, 25 March 2018, https://fissilematerials.org/library/usn18b.pdf.

[13] Congressional Research Service, *Navy Next-Generation Attack Submarine (SSN[X]) Program: Background and Issues for Congress,* 15 September 2021, https://sgp.fas.org/crs/weapons/IF11826.pdf.

[14] Sam LaGrone, "BWXT CEO: Navy's Next-Generation SSN(X) Attack Boat Will Build Off Columbia Class," *US Naval Institute News*, 2 November 2020, https://news.usni.org/2020/11/02/bwxt-ceo-navys-next-generation-ssnx-attack-boat-will-build-off-columbia-class.

[15] Director, Naval Nuclear Propulsion, *Report on Use of Low Enriched Uranium in Naval Nuclear Propulsion,*1995, https://fissilematerials.org/library/onnp95.pdf.

[16] US DOE, *Tritium and Enriched Uranium Management Plan Through 2060* (2015) https://fissilematerials.org/library/doe15b.pdf; US DOE, "Secretary Brouillette Announces The Nuclear Fuel Working Group's Strategy To Restore American Nuclear Energy Leadership" (2020) https://www.energy.gov/articles/secretary-brouillette-announces-nuclear-fuel-working-groups-strategy-restore-american.

[17] US DOE, *Tritium and Enriched Uranium Management Plan Through 2060*.

[18] Amendment 410 to H.R. 4350 National Defense Authorization Act for FY 2022, Rules Committee Print 117-13, 7 Sept. 2021, offered by Mr. Foster of Illinois. https://amendments-rules.house.gov/amendments/FOSTER_063_xml210914110049511.pdf.