GLOBAL ENTERPRISE TO STRENGTHEN NONPROLIFERATION AND DISARMAMENT

DISCUSSION PAPER: MANAGING RISKS OF FISSILE MATERALS

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I. Fissile materials management: Why it matters

Fissile materials management is an essential component of the nuclear nonproliferation and disarmament regime. The path toward a world without nuclear weapons must be accompanied by steps that build confidence, through verification and other transparency measures, in three areas: (1) ensuring that we can account for all fissile materials – quantities, types, and locations; (2) working to ensure that all fissile materials are safe, secure, and are not being diverted for military purposes; and (3) reducing the overall risks posed by these materials through minimization and, where possible, elimination of these materials. Unless we can track and secure fissile materials, a disarmed world can only exist in our imaginations. Progress on disarmament has been slow, and will likely continue to be slow, but progress on building the fissile materials management architecture that must accompany a world with lower numbers of nuclear weapons and eventually a nuclear-weapon-free world can and must be pursued now.

These steps are of course vital for the nonproliferation and disarmament regime's long-term success, but securing, minimizing, and eliminating these materials is also necessary to prevent catastrophic nuclear terrorism – a near-term threat that must be addressed in today's world, as well as tomorrow's. Approximately 1,800 tonnes of plutonium and highly enriched uranium (HEU) are located in 22 countries around the world. The security of these materials is not governed by any set of international standards or rules of the road, and there is no governing body to provide oversight or accountability over these materials. States are left to decide how to secure those materials, but security standards vary greatly around the world. Moreover, an improvised nuclear device that a terrorist could build and use in a terrorist attack requires only small amounts of material. According to the IAEA, a nuclear explosive device could be made with only 8 kilograms of plutonium and only 25

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kilograms of HEU.[1] Putting it more starkly, this amounts to enough HEU to fill a bag of sugar and a quantity of plutonium the size of a grapefruit. That's all the material it takes for a nuclear device that could devastate one of our cities.

This paper attempts to outline the key recent developments in the area of managing fissile material risks, describe the challenges facing that process, and suggest measures that could help reduce these risks, strengthen the nuclear nonproliferation regime, and support nuclear disarmament.

II. Background

For the purposes of this paper, the term "fissile material" means the material that can be used to manufacture a nuclear explosive device.[2] The global stock of weapon-usable fissile materials is estimated to include about 520 tonnes of separated plutonium and 1,340 tonnes of HEU. About 290 tonnes of that plutonium and 22 tonnes of HEU are civilian materials; the rest are fissile materials associated with military programs. Of these amounts, 89 tonnes of plutonium and 85 tonnes of HEU in the military stock are covered by various obligations that preclude their use in weapons.[3] This means that about 140 tonnes of plutonium and 1,240 tonnes of HEU are currently available for use in nuclear weapons. That is enough material to build more than 35,000 nuclear weapons, which is far beyond the numbers that already exist.

The total number of nuclear weapons in active arsenals of the nine states that possess them is believed to be about 9,300.[4] These weapons can be estimated to contain approximately 40 tonnes of plutonium and 230 tonnes of HEU. The remainder of weapon-usable nuclear material is in retired weapons, weapon components, or in other forms.

Four nuclear-armed states – France, Russia, the United Kingdom, and the United States – officially ended production of fissile materials for nuclear weapons. China is believed to have stopped producing materials for weapons as well. India, Israel, North Korea, and Pakistan either continue production of fissile materials for weapons or maintain dedicated weapon-usable material production facilities. Six states – China, France, Russia, the United Kingdom, Japan, and India – operate civilian reprocessing plants that separate plutonium from spent fuel of power reactors. Eleven states – Argentina, Brazil, China, France, Iran, Japan, Russia, the United States, the United Kingdom, Germany, and the Netherlands (these

[1] This is known as a "significant quantity," which the IAEA defines as "the approximate amount of nuclear material for which the possibility of manufacturing a nuclear explosive device cannot be excluded.
[2] The term that is used in the IAEA safeguards context is "unirradiated direct use material." *IAEA Safeguards Glossary* (Vienna: International Atomic Energy Agency, 2002), 4.25. From the practical standpoint, the most relevant materials are highly enriched uranium (HEU) that contains more that 20% of the isotope uranium-235, and separated plutonium.
[3] Moritz Kütt, Zia Mian, and Pavel Podvig, "Global Stocks and Production of Fissile Materials, 2017," in *SIPRI Yearbook 2018: Armaments, Disarmament and International Security* (Stockholm: SIPRI, 2018), 288–94.
[4] Shannon N. Kyle and Hans M. Kristensen, "World Nuclear Forces. Overview," in *SIPRI Yearbook 2018: Armaments, Disarmament and International Security* (Stockholm: SIPRI, 2018), 235–36.

last three are in the URENCO consortium) – operate civilian enrichment plants that produce low-enriched uranium (LEU) to fuel nuclear power reactors. One of the enrichment plants in Russia is also producing HEU for civilian applications.[5]

There are several risks associated with fissile materials: (1) Non-Nuclear Weapon States (NNWS) with existing stocks of these materials – particularly those with large stocks – can potentially use them to produce new weapons, which raises concerns about the strength of their commitments to nuclear disarmament and creates verification challenges that will have to be addressed in the disarmament process; (2) States with relatively small nuclear arsenals continue to produce materials for weapons; (3) There are proliferation risks associated with the spread of fissile material production technologies and facilities for peaceful purposes; and (4) last but not least, the presence and use of weapon-usable fissile materials creates a continuously evolving and ever-present nuclear security risk of theft or misuse of these materials.

These risks have been widely recognized and the international community has invested significant efforts in reducing them. The Conference on Disarmament (CD) has been tasked with negotiating a treaty that would ban production of fissile materials for weapons (the Fissile Material Cutoff Treaty, or FMCT). Fissile material risks have been repeatedly addressed in the context of the Treaty on the Non-proliferation of Nuclear Weapons (NPT) – the Action Plan adopted at the 2010 NPT Review Conference (RevCon) called on member states to begin FMCT negotiations, declare more material as excess to military uses and place excess material under safeguards, and convert or dismantle production facilities that were used to produce weapon materials. The security of nuclear materials was recently the subject of the Nuclear Security Summit process. There have been a number of national and international programs aimed at consolidating and eliminating fissile materials, HEU in particular, and reducing the use of HEU in civilian applications. In addition, the IAEA's Division of Nuclear Security provides major contributions to nuclear security through its guidance documents and advisory services, as well as workshops, training, and coordination of Centers of Excellence and Nuclear Security Support Centers.

III. Options for cooperative engagement

This section outlines areas in which cooperative engagement may be possible, as well as specific options to make progress in these areas from which states can draw ideas for actions and commitments they can take in the context of deliverables for the 2020 NPT RevCon. The section is organized by the three core elements of the fissile materials management architecture described in the opening section: accounting and tracking of

[5] India, North Korea, and Pakistan operate enrichment plants that produce HEU for weapons or other military applications. Russia may be also producing HEU for naval reactors. Brazil may be producing LEU for its naval reactor program. The enrichment plant in Japan operates at very low capacity. The enrichment facilities in Iran are pilot plants that are currently in limited operation. Moritz Kütt, Zia Mian, and Pavel Podvig, "Global Stocks and Production of Fissile Materials, 2017."

fissile materials; securing and safeguarding materials; and minimizing and eliminating weapons and materials. A fourth section looks at options for progress on the FMCT.

A. Fissile materials accountability

Real progress on lowering the number of nuclear weapons and eventually reaching zero requires the ability to track and account for nuclear materials that can be used in weapons with high confidence. This requires establishing a baseline of global material stocks as well as mechanisms to ensure transparency and accounting of materials moving forward. Transparency regarding fissile material stocks also plays an important role in creating conditions for managing the risks associated with these materials. It could also be an element of a compromise in the FMCT process (see discussion at the end of the paper) – a number of proposals suggest that the issue of stocks can be addressed through voluntary transparency and confidence-building measures implemented outside of the formal treaty structure. The FMCT could also include stronger transparency measures, such as a requirement to provide a declaration of stocks.

The following options would provide much-needed transparency to enable the international community to set a baseline of stocks and continue to track stocks of materials over time.

Option 1: Provide Information about Fissile Material Stocks

There are a number of steps that could prepare ground for future work on verifying material declarations and establish transparency as a norm in fissile material management. Importantly, some of these steps build on existing practices, and most could be championed by NNWS.

Any of these approaches, however, would require a significant degree of transparency on the part of nuclear-armed states. So far, only the United States has demonstrated willingness to provide information about its fissile material stocks. It published a detailed account of its plutonium and HEU balances and provided updates of that information. The United Kingdom also published information about its plutonium and HEU stocks, although the information was not as comprehensive as that provided by the United States. **All nuclear-armed states should be encouraged to join the United States and the United Kingdom and release information about their fissile material holdings, including the amount of material in military programs.** Even if this information is released in the most basic form, as aggregate amounts of plutonium and HEU, it would be an important confidence-building measure while also protecting sensitive information.

NNWS can also take a step toward establishing transparency as a norm in handling fissile materials by publicly releasing information about their stocks. This information is already available to the IAEA as part of the NPT safeguards administered by the agency, so its public release would not require substantial effort. Releasing this information would strengthen the position of those who call on Nuclear Weapon States (NWS) to disclose information

about their fissile material stocks, civilian as well as military, and would help develop a better understanding of the challenges that such a disclosure would entail, such as its nuclear security implications. Releasing information about current stocks in NNWS could also be a first step in developing arrangements that would verify the correctness and completeness of declarations about past production of fissile materials in nuclear-armed states. Some NNWS produced weapon-usable fissile materials in the past, and their experience in accounting for that production would be extremely valuable.

Option 2: Improve Reporting under the IAEA's INFCIRC/549 Plutonium Management Mechanism

Under this mechanism, named after INFCIRC/549, an IAEA document that outlines plutonium management guidelines agreed on by nine states in 1998,[6] participating states publish annual declarations of the amount of separated plutonium under their control. These declarations have established an important norm of transparency in managing civilian plutonium. **This mechanism can be significantly improved, however, so the data submitted in declarations provide more accurate and detailed information about movements of civilian plutonium.** One option would be for participating states to adopt the more detailed reporting format of the annual reports on the status of plutonium management published by Japan.[7]

Option 3: Improve Implementation of the IAEA's INFCIRC/912 Mechanism for Managing HEU

An attempt to create a similar transparency measure for HEU was undertaken by a group of more than 20 states as part of their commitment at the 2016 Nuclear Security Summit to reduce the use of HEU in civilian applications.[8] The corresponding statement was published as IAEA document INFCIRC/912 in February 2017. According to the INFCIRC/912 commitment, the first reports on HEU stocks could cover historical activities. These initial reports could provide a chance for states that operated HEU facilities in the past to work together on reconstructing the history of HEU use, thus providing a useful baseline against which to assess stocks in the future.

None of the subscribing states, however, have released their reports, which were expected to be submitted in May 2017. **States that signed the INFCIRC/912 statement should be encouraged to fulfill their commitment and submit reports about historical HEU activities and current HEU stocks.** This activity could make an important contribution to transparency

[6] The participating states are Belgium, China, France, Germany, Japan, Russia, Switzerland, the United Kingdom, and the United States.
[7] See, for example, "The Status Report of Plutonium Management in Japan - 2017" (Office of Atomic Energy Policy, July 31, 2018), http://www.aec.go.jp/jicst/NC/about/kettei/180731_e.pdf.
[8] The original participants were Argentina, Armenia, Australia, Canada, Czech Republic, Chile, Denmark, Finland, Georgia, Mexico, Netherlands, Nigeria, Norway, Philippines, Poland, Republic of Korea, Romania, Singapore, Sweden, the United Kingdom, and the United States. Malaysia and Luxembourg joined the initiative in 2018.

of fissile material stocks and provide a valuable opportunity for international cooperation in fissile material management. It would bring together NWS and NNWS and could provide an opportunity to involve Russia, which provided HEU fuel for more than a dozen foreign research reactors and which remains the largest user of HEU in civilian applications today.

Option 4: Increase the Stocks of Fissile Materials Declared Excess to Weapon Purposes

Nuclear-armed states could increase the stocks of fissile materials declared excess to weapon purposes.[9] This would mean an increase in the amount of global stocks of fissile materials subject to accounting and transparency measures. Most nuclear-armed states have fissile material far in excess of what is required to maintain their current weapon arsenals. Some of that material has been declared excess, and substantial amounts of weapon-usable fissile materials – about 680 tonnes of HEU and more than 10 tonnes of plutonium – have been eliminated or disposed of. This process, however, has slowed down considerably in recent years. No additional material has been declared excess since 2005.

In most cases, nuclear-armed states have more material that can be identified as excess to military requirements. One proposal that has considerable support of NNWS, whether in the context of FMCT discussions or in the general context of nuclear disarmament, calls on nuclear-armed states to make all fissile material that is not used in weapons available to the IAEA (or similar organization) for safeguards. However, no nuclear-armed state has so far expressed readiness to declare additional material as excess to military requirements.

Option 5: Place Excess Material in Monitored Storage while it is Awaiting Disposition

To facilitate the process of removing excess material from weapon programs it is necessary to **develop simple and reliable methods of placing excess material in monitored storage while it is awaiting disposition**. One approach would follow the work previously done by the Trilateral Initiative, probably by focusing on less intrusive or simpler verification methods based on information barriers, though this has not yet been developed.[10] It should be understood, however, that the need to protect sensitive information about the material will always bring additional cost, complexity, and nuclear security risk to the program.

Approaches that do not deal with sensitive information should be explored as well. In most cases, the most practical way to configure a disposition program would be to place material

[9] The concept of excess material that is used in this discussion describes fissile material that states have no intention or need to use in weapons or for military purposes. It does not imply any status of the materials that are not included in this category.

[10] The Trilateral Initiative was a joint U.S.-Russia-IAEA program that explored the means for the IAEA to monitor classified forms of weapon-origin fissile materials. The program developed verification methods that allowed to confirm the presence of plutonium, the fact that the mass of plutonium exceeds a certain threshold, and the fact that the plutonium has "weapon-grade" isotopic composition. Sensitive information about the actual mass of the material and isotopic composition was protected by an information barrier. Thomas E. Shea, "Weapon-Origin Fissile Material: The Trilateral Initiative," in *Global Fissile Material Report 2008: Scope and Verification of a Fissile Material (Cutoff) Treaty* (International Panel on Fissile Materials, 2008), http://ipfmlibrary.org/gfmr08.pdf.

in secure internationally monitored storage while it is in its original form, such as weapon components or weapons, until it is ready to enter the disposition process. While this would leave fissile materials in the weapon form for considerable time, properly designed monitoring arrangements could ensure that the material is not returned to the weapon program.

Option 6: Resume Implementation of the PMDA with IAEA Monitoring

In a serious setback for the material elimination effort, in 2016 Russia and the United States effectively abandoned the bilateral Plutonium Management and Disposition Agreement (PMDA), which committed each party to eliminate 34 tonnes of weapon-grade plutonium. Even though the United States and Russia reaffirmed that they will not use the material included in the agreement for military purposes, it appears unlikely at this time that the PMDA will be implemented in full.

An important element of the PMDA that distinguished it from other programs was a provision that allowed the IAEA to monitor the disposition process. This element of the agreement can and should be preserved. The United States already took a step in that direction by inviting the IAEA to monitor its current non-PMDA plutonium disposition program. **The United States should confirm its earlier commitment to place its plutonium disposition program under IAEA monitoring. Russia should also allow the IAEA to monitor its disposition activities** (it will use plutonium to manufacture fuel for fast reactors). **If Russia will not allow IAEA monitoring, then it should be encouraged to provide information about its program, such as periodic reports on the progress of eliminating the 34 tonnes of the PMDA material.** It would be especially important to ensure that the program is using the weapon-origin plutonium and not the civilian stock.

Option 7: France and the United Kingdom Could Commit to Transparency Regarding their Stocks of Civilian Plutonium

Such a commitment by France and the United Kingdom could help establish transparency as a norm in the fissile material disposition. Information about these stocks should be readily available as they are currently covered by Euratom safeguards (the UK material will be covered by domestic safeguards once the United Kingdom leaves the European Union). France is using its material to manufacture MOX fuel for power reactors, so its experience can be applied to Russia's disposition program. **The United Kingdom is yet to determine the disposition path for its civilian plutonium, but it could make a commitment to place under IAEA monitoring any process that it eventually decides to implement.**

B. Securing and safeguarding fissile materials

Even under the most optimistic scenarios, very large quantities of HEU and separated plutonium will remain in use in a range of applications, civilian as well as military, for a very long time. These materials will have to be secured from theft and misuse throughout their

entire lifecycle. In addition, management of fissile materials, especially in a world with low numbers of nuclear weapons or a world with no nuclear weapons, requires confidence that fissile material is not being diverted from peaceful uses to military uses. International safeguards must be strong enough to provide all states with that confidence.

Option 8: Reinvigorate High-Level Support for Nuclear Security Summit Outcomes

Despite significant progress to secure, minimize, and eliminate nuclear materials and strengthen the global nuclear security architecture, there is no comprehensive global system for securing all nuclear materials. Such a system would have the following attributes: it would cover all nuclear materials, including the more than 80 percent of global stocks that are military materials; all states would adhere to international standards and best practices; states would take reassuring actions to build confidence in the effectiveness of their security practices; and states would work to reduce risk through minimizing and, where feasible, eliminating weapons-usable nuclear materials stocks.

The Nuclear Security Summits held in 2010-2016 proved instrumental in bringing high-level political attention to nuclear security and mobilizing governments to take concrete steps to strengthen the international nuclear security architecture and national nuclear security programs. The summit process led to important commitments by individual states and groups of states, such as the Joint Statement on Strengthening Nuclear Security Implementation (INFCIRC/869), in which states committed to implementing IAEA nuclear and radiological security guidance, and Joint Statement on HEU minimization (INFCIRC/912). It also resulted in commitments by states to ratify the Amendment to the Convention on the Physical Protection of Nuclear Material (CPPNM), enabling it to enter into force in 2016. The Nuclear Security Summit also resulted in the creation of a Nuclear Security Contact Group that provides an ongoing forum for further discussions of relevant issues. The commitments made at the Summits, the CPPNM obligations, existing IAEA nuclear security regulations, and institutions like the World Institute for Nuclear Security (WINS), provide a solid basis for strengthening the nuclear security regime.

Given gaps in the architecture, and a slowing of progress and attention on nuclear security, more work is needed to reinvigorate high-level political attention on nuclear security to enable continued progress on nuclear security and further strengthen the global architecture following the end of the Nuclear Security Summit process. **States should therefore support the Nuclear Security Contact Group, the IAEA's nuclear security work, as well other institutions and initiatives that advance nuclear security progress.**

Option 9: Explore Ways to Establish Cooperation in Strengthening Security of Military Fissile Materials

One of the problems that all these mechanisms have to deal with is the sensitive nature of nuclear security arrangements that complicate assessment of the effectiveness of measures undertaken by individual states. As physical protection is the responsibility of a state, in

most cases self-assessment remains the primary (and often the only) tool for evaluating national nuclear security programs. The existing peer review mechanisms, such as the IAEA International Physical Protection Advisory Service (IPPAS) missions, can partially address this gap, but these missions may not have full access to some key elements of the nuclear security system, such as the design basis threat or the physical protection infrastructure. IPPAS missions are only undertaken at the request of states, and their scope and composition of experts is decided by the requesting state.

Many states argue that the need to protect information about specifics of nuclear security arrangements prevents implementation of measures that have demonstrated their effectiveness in other areas, such as safety of nuclear power plants or transportation. These would include exchange of information about best practices, sharing data about specific technical arrangements, joint analysis of accidents and lessons learned.

This gap is especially visible when it comes to physical protection of materials in military use, which account for more than 80% of the global fissile material stock.[11] In most cases, the regulatory and security arrangements implemented for these materials are different from those applied to the materials in the civilian domain. Even if the security arrangements for military materials are designed to be stronger, their relative lack of transparency might create unforeseen vulnerabilities in the system.

Progress in strengthening the nuclear security regime would depend on the willingness of states to **establish mechanisms that facilitate cooperation and transparency in securing military fissile materials**. Despite the oft-repeated need to avoid release of sensitive information, many of these activities can in fact be carried out without sharing information that could be misused in malicious ways. Concrete steps in other areas of fissile material management, such as a ban on production of fissile materials for weapons, elimination of excess materials, transparency of fissile material stocks, or HEU minimization could help build trust and confidence that would create the necessary conditions for such cooperation.

Option 10: Strengthen Existing Nuclear Security Mechanisms

States should take full advantage of the existing nuclear security instruments and arrangements. Among steps in this area would be:

- build awareness of the **INFCIRC/869** commitment to implement IAEA nuclear and radiological security guidance and to encourage more States to sign and implement it, which would be a step toward states following a common set of nuclear security standards;

[11] Mark Fitzpatrick et al., "Improving the Security of All Nuclear Materials" (International Institute for Strategic Studies, James Martin Center for Nonproliferation Studies, Vienna Center for Disarmament and Non-Proliferation, September 2016), http://www.nonproliferation.org/improving-the-security-of-all-nuclear-materials/.

- provide **information about nuclear security arrangements as required by Article 14.1 of the amended CPPNM**;
- commit to regularly **host IPPAS missions and publish their recommendations**;
- engage in **regional peer review mechanisms**, whether based on IPPAS or other arrangements.

Option 11: Offer all Fissile Material Production Facilities for IAEA Safeguards

One of the steps included in the Action Plan adopted by the 2010 NPT RevCon called on states to dismantle or convert to peaceful purposes the facilities used for the production of fissile materials for nuclear weapons. This step has been largely completed in those states that discontinued production of materials for nuclear weapons, as they no longer operate dedicated military facilities. At the same time, some converted production facilities, such as uranium enrichment plants and reprocessing facilities in China, Russia, and the United States, could theoretically be used to produce new weapon-usable materials, because they have not been placed under safeguards and are not covered by formal obligations not to produce materials of this kind.

Although it is unlikely that these facilities will be used to produce material for weapons, they are also unlikely to be verifiably converted to civilian uses unless the FMCT is in force. In the absence of FMCT, these facilities could be offered for IAEA safeguards. **At the minimum, nuclear-armed states should be encouraged to offer all their fissile material production facilities for IAEA safeguards.** Even though the IAEA normally does not implement safeguards in NWS due to resource constraints, a voluntary offer of facilities for safeguards would be a valuable step toward ensuring that these facilities have indeed been converted to civilian purposes.

C. Minimization and Elimination of Fissile Materials

Option 12: Declare a Fissile Material Production Moratorium for Weapons

China and states outside the NPT should be encouraged to declare and abide by a moratorium on fissile material production for nuclear weapons. To support the case for FMCT negotiations, it would also be **important that the NPT NWS that ended production of fissile materials for weapons (U.S., UK, Russia, and France) reaffirm their position**.

Option 13: Reduce Incentives for Construction of New Civilian Fissile Material Production Facilities

A number of states are expanding their civilian reprocessing programs and building breeder reactors, often despite evidence that the economic viability of a closed nuclear fuel cycle is questionable. Whether or not reprocessing will be sustained in the long term, it is almost certain that civilian reprocessing activity will expand in the next decade or so, leading to an

increase of the amount of separated plutonium in circulation.[12] So far, most of this activity has been concentrated in nuclear-armed states (Japan is the only exception), and it appears that the lack of economic rationale for civilian reprocessing will prevent further spread of the technology. However, the existing and new reprocessing plants and the material they produce will certainly complicate efforts to manage fissile material risks. To some extent, the FMCT could mitigate the disarmament and proliferation aspects of this problem, but it would not be able to address the nuclear security risks posed by the circulation of large amounts of weapon-usable civilian plutonium, which would not be impacted by the FMCT.

Containing the spread of uranium enrichment technology presents a different challenge. There is no good economic case for constructing new national enrichment facilities. The industry currently operates with significant excess capacity, and established suppliers could easily and competitively expand their capacity should the need arise. As a result, arguments for national enrichment focus on the assurances of supply, rather than on cost. These arguments spurred interest in various arrangements that would guarantee uninterrupted access to enrichment services, such as multinational regional enrichment centers or international banks of LEU. It is yet unclear if these arrangements will be successful (the IAEA LEU bank in Kazakhstan is still in development), but **the work on developing mechanisms of reliable fuel supply should continue.**

A somewhat different approach would **focus on strengthening the role of market mechanisms in providing assurances of supply.** This approach would take advantage of the diversity and overcapacity of the current uranium enrichment market to guarantee uninterrupted supply of fuel for power reactors.

Option 14: Continue the Effort to Minimize the Use of HEU in Civilian Applications

The HEU minimization program has significantly reduced the use of HEU in civilian applications and has helped remove the material from civilian facilities around the world. Since the early 1990s, the program completely removed HEU from 34 countries and from Taiwan. Research reactors that used HEU have been either converted to LEU fuel or shut down, and significant progress has been made in removing HEU from other civilian activities, such as medical isotope production. Importantly, the program, largely supported by the United States, provided an example of successful international cooperation in the area of fissile material management.

The HEU minimization program has already created several de facto HEU-free zones in Central and Eastern Europe, Latin America, South East Asia, and most of Africa. **Creating and**

[12] See, for example, John Carlson, Leonard S. Spector, and Miles A. Pomper, "The Other Fissile Material: Strengthening National and International Plutonium Management Approaches" (James Martin Center for Nonproliferation Studies, December 2018), https://www.nonproliferation.org/wp-content/uploads/2018/12/op42-the-other-fissile-material.pdf.

formalizing zones free of HEU could be a valuable instrument in strengthening the norm against civilian use of HEU.

By 2019, the effort to reduce the use of HEU in civilian applications has reached the point where further progress has become more difficult, as the remaining cases of HEU use are more challenging. For example, conversion of high-performance research reactors that use HEU requires development of advanced LEU fuels. This work is underway in the United States and Europe, but it will not be completed until at least 2030. The program also suffered a setback when Russia, which operates more than half of all HEU reactors and research facilities, pulled out of the US-Russian reactor conversion program in 2015. In 2012, Russia restarted production of HEU for research and fast neutron reactors. This Russian material is exported to China, France, and Germany; some of it may be used in fuel of new Russian icebreakers.

An effort should be made to **encourage other states to join the INFCIRC/912 HEU minimization commitment, especially those that operate HEU facilities—France, Germany, and Russia.** As discussed earlier, the reporting mechanism of INFCIRC/912 could make a valuable contribution to the transparency of fissile material stocks.

Option 15: Expand the HEU Minimization Effort Beyond Research and Isotope Production Reactors

Although the removal of HEU from research reactors and other similar applications plays an important role in strengthening the norm of non-use of HEU for civilian purposes, these applications consume a fairly small amount of the material. In the civilian sector, much larger quantities of the material are used in fuel of Russian nuclear-powered icebreakers or in fuel of some breeder reactors. HEU is also used in military research reactors and in naval reactors. **States should consider developing a comprehensive program of minimizing the risks associated with HEU that would account for the use of HEU in naval, transport, and power reactors**.

D. Fissile Material Cut-off Treaty (FMCT)

All of the above measures should be taken regardless of whether there is an FMCT in place. However, the effort to negotiate a treaty to ban production of fissile materials for weapons has been, and will continue to be, an important element of the process of advancing nuclear disarmament and strengthening the nuclear non-proliferation regime. The CD, which has the mandate to negotiate the treaty, remains deadlocked after two decades, and the prospects for the beginning of FMCT negotiations are highly uncertain. The Group of Governmental Experts (GGE) and the High-Level Expert Preparatory Group (HLEPG) that worked in 2014-2018 provided an opportunity for a detailed discussion of key elements of the treaty, but as they were not negotiating bodies, they could not address disagreements between different approaches to the substance of the treaty. Elements of the treaty were

discussed by one of the CD subsidiary bodies in 2018, but that discussion was limited in scope.

It is important to take into account that even if the deadlock at the CD is overcome (or the issue is taken to a different forum), negotiators will have to deal with competing visions of the role the treaty should play in the international security architecture. Many states believe that the FMCT should be an instrument of nuclear disarmament and therefore should include provisions that address existing stocks of fissile materials. Most nuclear-armed states do not support this approach, arguing that the treaty should focus on future fissile material production and leave disarmament provisions outside of its scope.

These differences, however, do not have to be irreconcilable. Even a treaty with a narrow scope – for example, a treaty that only covers future production of weapon-grade (as opposed to weapon-usable) materials – could have a significant disarmament value if it creates a system that would monitor all fissile material production facilities. The verification system established by such a treaty would also be capable of accepting any future excess or disarmament material and ensuring its verified and irreversible disposition.[13] The role of the treaty as an instrument of nuclear disarmament could be further strengthened by including provisions that would support verifiable declarations of fissile material stocks.[14]

If successfully negotiated, the FMCT could indeed become an important element of a regime that could potentially cover all aspects of fissile material management. In addition to stopping production of fissile materials for weapons, the treaty would create legal and institutional infrastructure to support a range of verification and reporting activities. The treaty could also incorporate measures that would help strengthen nuclear security. These factors make a strong case for pursuit of FMCT negotiations. Several options to advance the negotiation could be considered.

Option 16: Declare Continuing Support for Negotiations at the 2020 NPT Review Conference

At a minimum, parties at the 2020 NPT RevCon should declare their continued support for negotiating an FMCT. They should also commit to identifying solutions to overcome barriers that prevent negotiations from moving forward.

Option 17: Maintain Momentum of FMCT-related Groups

The work of the GGE and the HLEPG provided a valuable foundation for future FMCT deliberations as they identified key points of disagreement, as well as areas of consensus. At this point, it would be important to **establish a process associated with the CD that would**

[13] Pavel Podvig, "Fissile Material (Cut-off) Treaty: Elements of the Emerging Consensus" (UNIDIR, 2016), http://www.unidir.org/files/publications/pdfs/fissile-material-cut-off-treaty-elements-of-the-emerging-consensus-en-650.pdf.

[14] Pavel Podvig and Joseph Rodgers, *Deferred Verification: Verifiable Declarations of Fissile Material Stocks* (UNIDIR, 2017), http://www.unidir.ch/files/publications/pdfs/deferred-verification-verifiable-declarations-of-fissile-material-stocks-en-694.pdf.

provide a forum for developing an approach to FMCT that would allow it to begin actual negotiations. This could be done through the work of CD subsidiary bodies or similar fora. It may be useful to consider establishing a Group of Scientific Experts that would examine technical issues related to the treaty implementation. This Group could, for example, **develop and test in practice approaches to handling fissile materials released in the nuclear disarmament process**, building on the work of the UK-Norway Initiative, the Quad Partnership, and the International Partnership on Nuclear Disarmament Verification. It could also consider approaches to verifiable declarations of fissile material stocks.

Option 18: Move FMCT Negotiations to an Alternate Forum

It may be possible for a treaty negotiated outside of the CD to establish a strong norm of not producing material for weapons and to create a robust verification system. An attempt to take the negotiations to a different forum, however, may not receive support of some nuclear-armed states, which would limit the value of an agreement that such a forum might produce. However, the benefits of this option should be considered, including potentially using another forum to address barriers to progress, build a better understanding of security concerns of states, and make progress on substantive questions, but then returning it to the CD for final negotiation.

IV. Conclusion

There is a broad set of measures that could help address various aspects of fissile material risks. Some of these measures could be implemented relatively easily, others would require a sustained effort and probably a change in the political climate. On the other hand, some of these steps could facilitate that change by building trust and promoting cooperation among all states that have a stake in nuclear disarmament, non-proliferation, and nuclear security. It is important to build on the progress that has been made so far in ending the production of fissile materials, shutting down and dismantling military production facilities, eliminating hundreds of tonnes of weapon-usable materials, reducing the use of HEU, and strengthening the nuclear security regime.