Improving the security of *all* nuclear materials:

Legal, political, and institutional options to advance international oversight

September 2016

Report by the International Institute for Strategic Studies (IISS), the James Martin Center for Nonproliferation Studies (CNS) and the Vienna Center for Disarmament and Non-Proliferation (VCDNP)

Commissioned by the Government of Switzerland

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Acronyms

BARC	Bhabha Atomic Research Center
CNS	James Martin Center for Nonproliferation Studies
CPPNM	Convention on the Physical Protection of Nuclear Material
CPPNMNF	Convention on the Physical Protection of Nuclear Material and Nuclear Facilities
DOE	(US) Department of Energy
EURATOM	European Atomic Energy Community
FMCT	Fissile Material Cut-off Treaty
FMWG	Fissile Materials Working Group
GICNT	Global Initiative to Combat Nuclear Terrorism
HEU	High enriched uranium
HEUMF	Highly Enriched Uranium Materials Facility
IAEA	International Atomic Energy Agency
ICSANT	International Convention for the Suppression of Acts of Nuclear Terrorism
INTERPOL	International Criminal Police Organization
IISS	International Institute for Strategic Studies
INFCIRC	Information Circular(s) (IAEA official communications)
IPPAS	International Physical Protection Advisory Service
LEU	low enriched uranium
MOX	mixed oxide
NPT	Nuclear Non-Proliferation Treaty
NSS	Nuclear Security Summit
NTI	Nuclear Threat Initiative
NWS	Nuclear-weapons state(s) under the NPT
P5	5 Permanent members of UNSC (sometimes used as shorthand for NWS)
PMDA	Plutonium Management and Disposition Agreement
SUA	Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation
SUA PROT	Protocol for the Suppression of Unlawful Acts against the Safety of Fixed Platforms located on the Continental Shelf
UNSCR	United Nations Security Council resolution
VCDNP	Vienna Center for Disarmament and Non--Proliferation

Executive Summary

About four-fifths of the weapons-usable nuclear materials in the world are in non-civilian programmes. This means not only as the explosive core in active or reserve nuclear weapons, but also as fuel in naval and military research reactors, highly enriched uranium (HEU) and plutonium at production sites, in storage, or declared excess to military uses, but not yet transferred to other programmes or eliminated. Yet coordinated global efforts to enhance the security of nuclear materials have been almost exclusively concentrated on the estimated 17% of such nuclear materials in the civilian sector.

Ideally, all HEU and plutonium of the same grade should have at least the same level of adequate security regardless of the possessor or purpose, since the materials pose the same threat. In practice, however, the security of materials can vary depending on whether they are used in the civilian or military sectors. The Convention on the Physical Protection of Nuclear Material and Nuclear Facilities (CPPNMNF – as the Convention on the Physical Protection of Nuclear Material was renamed after the 2005 amendment came into force in May 2016), as well as International Atomic Energy Agency (IAEA) security guidelines such as INFCIRC/225/Rev.5, describe how civilian materials should be secured. No such explicit guidelines exist on how to secure materials outside of the civilian sector. Nor is there comprehensive public knowledge about the state of security of such materials in all countries with nuclear weapons programmes.

It has often been asserted that nuclear materials in non-civilian use are well protected because they are under military control. However, the number of troubling security breaches involving nuclear material in military use, as well as some examples involving civilian nuclear facilities, belies this casual assumption, underscoring why the world should not simply accept the unsubstantiated 'solemn word' of authorities that security is as tight as needed. The list of incidents includes insider threats, peaceful incursions for demonstration purposes, theft, armed attack, and, most recently, over-flights by drones and computer hacking. Our report includes a number of examples of incidents at civilian facilities as well because they demonstrate areas of vulnerability that may also apply to the non-civilian sector. The record offers a compelling case for why security must be enhanced for *all* nuclear material.

On the whole, the Nuclear Non-Proliferation Treaty (NPT)-recognised nuclear-weapons states (NWS) have been decreasing their stocks of nuclear weapons-usable material. They have reduced their number of nuclear weapons and declared weapons-usable material in defence programmes as excess to military needs, thereby opening up an opportunity to eliminate large quantities of HEU by downblending and to recycle excess plutonium in reactors or to dispose of it in other ways. However, when weapons-usable material is no longer in nuclear weapons or naval fuels, it poses a different risk as material is moved to a variety of facilities

with different security protocols. The concern is that the weapons-usable material could be intercepted in transport, or stolen from the facilities themselves. In recommending a 'Stored Weapons Standard', a 1994 US National Academies report on the disposition of plutonium argued that a 'stringent standard of security and accounting must be maintained throughout the disposition process, approximating as closely as practicable the security and accounting applied to intact nuclear weapons'.[1] The idea of a uniformly high standard for protecting weapons-usable materials at all times and all places makes good sense. The security protocol for weapons-usable materials moving from military to civilian sectors or from assembled weapons to components within the military sector should not change unless the materials are denatured (that is to say, their sensitive characteristics are removed, such as through the downblending of HEU).

To date, the array of legal instruments, United Nations (UN) resolutions, IAEA recommendations and guides, technical advisories and diplomatic initiatives that comprise the fragmented and incomplete global nuclear security regime has been geared primarily toward securing nuclear materials in civilian use. The security of nuclear materials in non-civilian use has largely been left to states themselves to implement as they best see fit. Legal and political options for making progress on measures to ensure the security of nuclear materials not in civilian use are currently limited. Of the multitude of instruments, initiatives, and other measures discussed in this report, some hold greater promise for application to *all* nuclear materials than others.

The authors of this report offer four substantive recommendations for strengthening the security of all nuclear materials: a) minimisation, elimination, and consolidation; b) voluntary application of civilian norms, recommendations, and guidelines to *all* nuclear materials; c) exercises, training, and sharing of best practices; and d) transparency and reporting.

The authors have identified three different approaches to effectuating these norms and recommendations, some of which are more applicable to some of the recommendations than to others.

The **first** is to take advantage of existing multilateral fora which do not explicitly distinguish between civilian and military nuclear materials: these include the UN Security Council, UN General Assembly and the Global Partnership against the Spread of Weapons and Materials of Mass Destruction (the Global Partnership). This could be achieved through the full and effective implementation of the United Nations Security Council resolution (UNSCR) 1540 requirements, adoption of new resolutions by the UN General Assembly and/or Security Council, and inclusion of military experts in cooperative projects, exercises, training, and sharing of best practices under the Global Partnership.

The **second approach** would be to seek to extend to all nuclear materials the existing commitments made in multilateral fora, such as the IAEA and the Nuclear Security Summits (NSS), that currently apply only to civilian materials. A particularly useful mechanism to achieve that expansion could be through the Contact Group established by some of the NSS participants, who could advance the summit outcomes in IAEA fora such as the annual General Conference (GC) and ministerial conferences on nuclear security.

IAEA member states could also individually and collectively promote voluntary application of IAEA recommendations and guides to all nuclear materials. Since 2013, member states have started including references to the security of all nuclear materials, including those in weapons programmes, into the IAEA GC resolutions on nuclear security. Such references were also included in the final declaration of the 2012 ministerial conference on nuclear security. IAEA member states should continue including reference to the responsibility of states 'to maintain effective nuclear security of *all* [italics added] nuclear and other radioactive material' and 'at all stages in their life cycle' into key IAEA resolutions and declarations on nuclear security.[2]

The **third approach** would be to establish, or make use of, existing technical or working level efforts among the nuclear-armed states to advance best practices and norms in this area. This could involve agreement on the possible procedures or standards for the exchange of information on the conceptual approaches to the security of military materials and sites, including methodology, regulatory arrangements, training, and other issues. These technical or working level efforts could be pursued in the P5 Process, through specially established

technical working groups, and through Track 1.5 or Track 2 meetings.

The first of our substantive recommendations involves the **minimisation, elimination, and consolidation** of weapons-usable nuclear materials. A variety of unilateral, bilateral, or multilateral efforts could be pursued, including the anticipated 2018 international conference on HEU minimisation and elimination announced by Norway at the 2016 NSS. Continued efforts should be undertaken to build a global consensus on phasing out and eliminating the use of HEU from civilian and non-weapons applications. Supportive states could consider pledging to convert or shut down all HEU reactors, including pulsed reactors (most of which are in the military sector). Among other specific practical measures, the promotion of low enriched uranium (LEU) fuel for naval reactors would be an appropriate subject for France or others to raise in the P5 Process as well as within the HEU minimisation discussions in the NPT context. The issue could also be examined and realised through a technical working group, diplomatic discussions, and Track 1.5 or Track 2 fora.

To address excess stocks of military HEU and plutonium, we encourage the Russian Federation and the United States to get back on track in disposing surplus plutonium stocks they had agreed to eliminate in 2000 as part of the Plutonium Management and Disposition Agreement (PMDA). In addition, efforts in both HEU elimination and minimisation could be supported broadly through a General Assembly resolution echoing the 2010 NPT Review Conference Action Plan call for all NWS to put under IAEA or other relevant international verification all nuclear materials no longer required for military purposes, and requesting states to designate additional quantities for downblending to non-weapons form and other means of disposition. The minimisation and phasing out of HEU, the elimination of excess stocks, and the reporting and transparency of weapons-usable materials should continue to be addressed in the NPT review process as well.

The second substantive category of recommendations involves the **voluntary application of civilian norms, recommendations, and guidelines to all weapons-usable nuclear materials**. We do not mean to suggest that the civilian 'standards' established to date are sufficient, but they represent a minimum level of due diligence that should be applied to nuclear materials in all sectors. Washington and other supportive capitals should consider applying the full slate of guidance and other commitments captured by IAEA INFCIRC/869 to military materials. IAEA recommendations and guidelines with respect to civilian nuclear material security could also be applied to nuclear materials in military use, if a state decided to utilize them in that way. INFCIRC/225/Rev.5 explicitly notes that the recommendations contained therein, while intended for civilian use, can be used for 'other purposes'. Nuclear-armed countries could also be encouraged to follow other recommendations and guidelines set out in the IAEA's Nuclear Security Series. Although the IAEA's nuclear security publications are written with a view to their application to nuclear materials in civilian use, all those that address aspects of securing nuclear materials are also relevant to such materials in the military realm.

Additionally, states could use a future review conference of the Convention on the Physical Protection of Nuclear Materials (CPPNM) to extend its provisions to materials beyond the civilian sector.

In the **third substantive area**, more could be done to build on the hands-on experience derived from previous efforts, such as the US–Russia 'Nunn–Lugar' programmes and various bilateral and trilateral exchanges of best practices. Training exercises and demonstrations could also be conducted with participants from other countries. Global Initiative to Combat Nuclear Terrorism (GICNT) might represent one particularly useful vehicle for such exercises, given its joint US and Russian leadership. Supportive states could seek to have the Global Partnership involve military officials in programmes it funds which have applicability to all nuclear materials. The nuclear security Centres of Excellence in many of the nuclear-armed states (China, India, Pakistan, Russia, and the US) might serve as a means of providing training certification, as well as for sharing best practices. Supportive states could also consider a role for the IAEA in advising them whether their military nuclear security regulations conform to IAEA standards, akin to the advisory missions that the Agency already conducts. Peer reviews do not have to involve inspections of confidential facilities; they can take various forms, such as

exchanging views on personnel reliability programmes or security culture, for example. The review task could also be delegated to a 'trusted agent'.

Recommendations under **the fourth substantive area** include nuclear-armed states reporting to the international community to provide greater confidence that they are securing all nuclear materials, including materials in non-civilian use. The best venues for such reporting would appear to be the UN 1540 Committee, Article 14 of the CPPNMNF and ad hoc summits or ministerial meetings. The United States, for example, provided information, albeit limited, in its UNSCR 1540 reports and in its national reports to the last two NSSs. It also provided more detail on security within its nuclear weapons complex in the National Nuclear Security Administration's 2016 Stockpile Stewardship and Management Plan.[3]

In this regard, an analogy can be drawn to reporting on nuclear safety. Nuclear safety has evolved over time from being viewed as an issue for each state to manage in its own way to a matter of global concern requiring coordinated action. The regime of conventions that underpin global nuclear safety makes use of voluntary reporting by states above and beyond that which is required by the letter of the instruments in question. This could serve as a precedent for states party to a civilian-focused nuclear security convention to report on parallel activities in the military realm. In relation to the IAEA, the CPPNMNF review process represents the most viable instrument under which to pursue such reporting and other measures to strengthen the security for *all* nuclear materials, although such steps are likely to be of a voluntary nature.

As a final note, we observe that, while nuclear security is not directly linked to non-proliferation and disarmament efforts nor a substitute for such endeavours, it can both benefit from, and contribute to, both of these goals in a number of ways. Four potential benefits can be identified for disarmament. Firstly, the consolidation and minimisation of all weapons-usable nuclear materials and the elimination of surplus materials (civilian and military) serve both nuclear security and disarmament. The elimination of excess materials also prevents reconstitution of weapons. Where possible, the involvement of the IAEA or other external auditors in the elimination of excess nuclear materials would be highly desirable for transparency and verification. Secondly, accounting for and control and reporting of stocks of plutonium and HEU improves nuclear security, and could lay the foundation for the establishment of baselines, and monitoring and verification, under a Fissile Material Cut-off Treaty (FMCT) and other future multilateral disarmament efforts. Thirdly, joint exercises, peer reviews and similar activities with a focus on nuclear security could serve as building blocks for confidence-building measures and the development of trust in cooperative bilateral and multilateral efforts dealing with sensitive materials and facilities. Fourthly, the development of mechanisms and procedures for peer reviews, or other international review missions, with respect to the security of all nuclear materials, including military, and the development of best practices in securing these materials at all stages of their life cycle, would be important steps in developing a tool box for future disarmament verification and for ensuring that nuclear security is not compromised and sensitive information is not revealed during the disarmament process. The risk that disarmament efforts could actually increase the vulnerability of nuclear materials from weapons or military programmes would be minimised if these procedures and mechanisms were already developed, tested and implemented.

Table of Recommendations

APPROACHES RECOMMENDATIONS	Make use of existing fora that do not explicitly distinguish between civilian and military materials	Make use of existing fora currently limited to civilian materials	Create new fora, mechanisms or working-level efforts
Minimisation, elimination, and consolidation of HEU and plutonium	• UNGA & UNSC • NPT review process • P5 Process – encourage LEU naval fuel, convert or shutdown pulsed reactors • 2018 International Conference on HEU Minimization • Revive Russia–US plutonium disposition efforts • Post-NSS Contact Group	• IAEA General Conference • IAEA Ministerial-level Conferences on Nuclear Security	• Working group to develop HEU Management Guidelines or similar instrument (need not be limited to nuclear-armed states) • Technical working group and Track 1.5/Track 2 meetings on naval fuel replacement with LEU • New unilateral or multilateral elimination of HEU/plutonium excess to military programmes (and fulfilment of existing commitments to eliminate)
Voluntary application of civilian standards, norms, and recommendations to all nuclear materials	• UNGA and UNSC resolution 1540 • Post-NSS Contact Group	• IAEA – unilateral commitments to expand the scope of applicability of IAEA recommendations and guidelines • IAEA General Conference – resolution on nuclear security • IAEA Ministerial Level Conferences on Nuclear Security • CPPNMNF Review Conference	• Unilateral or group commitments to expand the scope of applicability of treaties and IAEA recommendations and guidelines to all nuclear materials
Exercises, training, sharing best practices	• Global Partnership against the Spread of WMD • P5 Process	• GICNT • Nuclear Security Centres of Excellence • World Institute for Nuclear Security	• Bilateral, trilateral and/or multilateral groups – share information; develop regulatory arrangements, training courses
Transparency and reporting	• UNSC resolution 1540 – implementation reports • NPT Review Conferences & Prep Coms • Unilateral declarations and reports • 2018 International Conference on HEU Minimization	• IAEA publications – voluntary unilateral, and ultimately universal, reporting on all stocks of HEU and plutonium • CPPNMNF – voluntary reporting on security arrangement • IAEA Ministerial-level Conferences on Nuclear Security • Plutonium Management Guidelines (and HEU Guidelines once they are put in place)	• Bilateral, trilateral and/or multilateral groups – develop mechanisms for increased exchange of information on stocks, legislation, security architecture, methodologies, use some forms of peer reviews or trusted agents

I. Introduction

The purpose of this report is to demonstrate that strengthening the security of *all weapons-usable* nuclear materials, not just those in the civilian sector, is of international concern, and to suggest ways that this can be achieved. Building upon previous work by the members of the project team, as well as other nongovernmental and governmental studies, this report details the risks attributed to military and dual-use nuclear materials and facilities and offers political, legal, and institutional policy recommendations for closing the gap between current means of addressing civilian and military nuclear materials in order to make nuclear security comprehensive.

The communiqués of the four Nuclear Security Summits have all spoken in terms of 'all' nuclear material. Yet the gift baskets and other NSS deliverables have largely been limited to civilian-use nuclear materials only.[4] The same is true of recent IAEA language: ministerial declarations and General Conference resolutions on nuclear security typically refer to *all* nuclear material, yet specific guidelines and recommendations are limited to the civilian sector. These lacunae highlight a dissonance between high-level political acknowledgement of the importance of ensuring proper security of military nuclear materials and the extent to which nuclear-armed states are prepared to take proactive steps beyond those they are implementing individually.

The almost exclusive focus of the NSS process on nuclear materials in civilian use only addresses an estimated 17% of all nuclear materials worldwide. The remaining 83% is under various forms of non-civilian control – and not just in nuclear weapons. Active warheads account for only 13% of all weapons-usable nuclear materials. As detailed in a 2015 report by the Nuclear Threat Initiative (NTI), the non-civilian category also includes materials in retired nuclear warheads awaiting dismantlement (8%), materials declared excess to military needs and awaiting downblending or disposition by governments (9%), materials in non-civilian naval reactors and military research reactors, materials designated for non-civilian naval reserves (13%), and materials designated for other non-civilian purposes, including bulk storage (37%).[5]

Three comments about nomenclature are necessary. Firstly, in discussing nuclear materials, 'non-civilian use' is generally a better term than 'military use' because of the common assumption that the latter exclusively means nuclear weapons, although this report uses both terms for the sake of convenience. Secondly, as reflected in the title of the report, the authors frame their recommendations and approaches in terms of the security of 'all' nuclear materials, rather than singling out non-civilian materials. Thirdly, 'nuclear material' is used as shorthand in this report to refer only to weapons-usable nuclear materials: HEU and separated plutonium.

In researching the topic, the authors interviewed officials from most of the nuclear-armed states, as well as well-connected non-governmental experts. Most of the

interviews were conducted on a not-for-attribution basis. Many of the experts assumed that the IAEA is the natural home and most representative institution for continued discussions of nuclear security following the conclusion of the NSS process. Officials from several countries, however, raised concerns about how this could realistically be achieved when it comes to non-civilian materials. Some insisted that the IAEA must remain a technical institution with a mandate to deal with civilian materials only, notwithstanding that the only legal inhibition is that, by its statute, the IAEA cannot 'further any military purpose'. Protecting against malevolent use or theft does not further a military purpose, which should negate any legal concerns about an IAEA role in enhancing the security of non-civilian materials. The greatest obstacles are politics and the risk of further politicisation. The IAEA is successful largely because it is a technical institution. The question is whether non-political ways can be found to enhance the security of all nuclear materials by building upon this expertise and knowledge.

There is also precedent for an IAEA role with respect to nuclear materials released from weapons programmes. The IAEA was involved in verifying the elimination of Iraq's nuclear weapons programme, in accounting for nuclear materials from the dismantled nuclear weapons programme in South Africa, and in developing mechanisms for the verification of fissile materials with classified characteristics declared excess to defence requirements as part of the Trilateral Initiative (with the United States and Russia). The verification concept developed under the Trilateral Initiative allowed classified forms of weapon-origin fissile material to be verified without revealing any secret information. During the IAEA Board of Governor's discussion of the Trilateral Initiative in June 1999, there was no serious challenge to the Agency's being involved in such an activity. In principle, the tools and processes developed under the Trilateral Initiative could be applied to excess military material in any country. Unfortunately, the initiative fell victim to the deteriorating bilateral relationship between Washington and Moscow.

Similarly, trilateral US–UK–Russia exchanges about nuclear security practices took place from 2008 to 2013.[6] Officials from each of the countries visited US and Russian sites, including sites that housed military materials, such as the US facility Y-12. Fairly high-level discussions were held during workshops and expectations for the process were positive until it too fell victim to the deteriorating political climate between Russia and the West.

This report was commissioned by the Government of Switzerland, which asked the project leaders to expand upon arguments they had made in two commentaries in 2015 calling for nuclear security principles and international oversight to apply to nuclear materials in the military sector.[7] Once the report was commissioned, the project team was accorded full academic freedom.

II. Risks attributed to military nuclear materials and facilities

This section provides an assessment of the risks attributed to weapons-usable nuclear materials associated with the military sector. The two weapons-usable materials are HEU (uranium enriched with 20% or more in the isotope of uranium-235) and plutonium extracted from spent nuclear fuel. Both types of weapons-usable material are used as the explosive fuel of a nuclear bomb but can also be used in the civilian sector. In examining past incidents, we look particularly at the risks at more vulnerable points of the production and overall life cycle of nuclear materials for military programmes and at facilities with overlapping military and civilian operations involving weapons-usable materials.

Publicly available information about security accidents and specific vulnerabilities at military sites is limited due to the secrecy and sensitivity of this information. Yet a good number of reports in the public domain highlight security lapses both at military facilities and at facilities that are not formally part of the military complex but produce, store, process, and eliminate materials associated with weapons programmes.

Building on a 2015 NTI report about the various purposes of non-civilian nuclear materials, we examine the risks of such materials inside and outside of nuclear warheads. Quite often, as demonstrated below, materials for or from weapons programmes and civilian materials are co-located within one facility or complex. Moreover, the incidents cited in the following section reinforce the assessment that nuclear materials in both the civilian and non-civilian sectors have long been susceptible to theft and misuse. Facilities housing these materials have been penetrated by protestors and criminals, including by armed groups. These examples are testimony to why security must be enhanced for *all* nuclear materials. Before discussing incidents that have occurred, we begin this section by describing the production, use and disposition of weapons-usable nuclear materials.

Life cycle stages of military-use nuclear materials

The life cycle of military materials consists of several stages. The **first stage** is the production of weapons-usable material, in the form of HEU or plutonium, from natural uranium, steps that may or may not rely on the civilian fuel cycle. The next stage is the processing and fabrication of the material for specific military applications. The third stage is the explicit employment of such material for military uses. The final stage, which may or may not occur under civilian control, is the removal of the material from military use and conversion of the material to lower risk materials and/or eventual long-term storage and disposition. In each stage, there are processing steps which physically change the material or change its configuration and thereby also modify the risk associated with the material. For example, in the first stage, enrichment plants can convert low enriched uranium (less than 20% U-235 enriched) into

weapons-grade (over 90% U-235 enriched) uranium, and spent nuclear fuel can be separated to extract plutonium (via a chemical process known as reprocessing). In both cases, the risk associated with the transformed material, if acquired by a non-state actor, goes from low to high.

The IAEA security guidelines for physical protection of nuclear materials and facilities, INFCIRC/225/Rev.5, reflect how this risk changes for material as it is processed: the level of protection required is higher if the material is converted into weapons-usable material. Other aspects of the material that affect its security are quantity and level of radioactivity. The strictest level of protection is for unirradiated weapons-usable material in quantities greater than two kg for plutonium and five kg for HEU.

The **second stage** represents the part of the process where materials are either manufactured as core elements for nuclear weapons to be transferred to the military or fabricated into fuel for naval reactors. In the US, the facilities that produce nuclear weapons form the 'nuclear weapons complex' and are government-owned and (civilian) contractor-operated. Naval reactor fuels are fabricated at facilities outside the nuclear weapons complex by companies contracted by the government. All of the eight major facilities that form the US nuclear weapons complex are managed independently, by different companies and consortia, and have different tasks within the complex. In Russia, naval fuel, for both civilian and military applications, is fabricated by a subsidiary of state company Rosatom.

The **third stage** is when nuclear weapons produced within the nuclear weapons complex are deployed by the military, or naval cores are used by navies (in the case of Russia, HEU naval-propulsion fuel is also used for icebreakers, i.e. civilian application). Deployed nuclear warheads and bombs, and reserve warheads and bombs stored at military bases, are all under military control, as are naval reactor cores that are used for military purposes. Because of the secrecy surrounding military facilities, not much is known about the quality of specific security arrangements for the materials under exclusive military control. However, as discussed later in this section, there have been several serious breaches of security at military controlled sites, both in the NPT NWS and in the other nuclear armed states, which call into question the security of nuclear weapons and other non-civilian weapons-usable materials that are under military control.

The **final stage** is when weapons-usable material is removed from retired nuclear weapons and either recycled for use in new nuclear weapons or stored in high-security facilities. In some countries, a portion of the weapons-usable material is declared excess. Material coming directly from warheads is usually declassified (or 'sanitised') before it is stored, or further processed to make it not weapons-usable.

HEU declared *excess* to military purposes can be downblended (diluted, essentially by mixing depleted uranium, natural uranium, or slightly enriched uranium with the HEU) to LEU, and fabricated into fuel for civilian reactors. In this case, the threat posed by the material is greatly decreased as it is no longer weapons-usable. One of a series of significant post-Cold War risk-reducing bilateral deals between the US and the Russian Federation was the Megatons to Megawatts programme, which provided for HEU from dismantled Soviet nuclear warheads to be downblended to LEU and used in the United States for power reactor fuel. The US pursued a similar (albeit smaller) HEU downblending programme on a unilateral basis, some of which was done under IAEA verification. As of the end of 2014, 660 tonnes of weapons-usable HEU excess to military needs was successfully downblended in Russia and the US.[8]

It is worth noting that downblending HEU reduces risks significantly; however, until the material has been converted to LEU, it still poses a serious risk and the security level must remain high, according to IAEA guidance, especially if it is fresh HEU fuel.[9]

Unlike HEU, plutonium is produced by irradiating uranium (whether natural or enriched), and then chemically separating the metal from the fuel. Once the plutonium used in a nuclear weapon is dismantled, it is removed from the weapon and either stored or declared excess to military use and further processed. All of the NPT NWS have ceased plutonium production for weapons purposes and a handful of them (the US, the Russian Federation, and the UK) have declared quantities of material as *excess to military use*, essentially taking the material out of the weapons programme.

Plutonium disposition is more complicated than HEU downblending because plutonium cannot be diluted with plutonium isotopes in a way that makes it unusable for weapons; plutonium can be chemically extracted from any compounds and used for nuclear weapons.[10] None of the existing options for plutonium disposition completely denature plutonium, unlike downblending uranium. One method of plutonium disposition is to fabricate the plutonium into mixed oxide (MOX) fuel containing uranium oxide and plutonium for use in civilian power reactors or fast reactors. After use, the spent fuel can again be reprocessed and refabricated into fast-reactor fuel, which still poses a proliferation risk since it has been broadly accepted that all forms of plutonium extracted from spent fuel can be used for nuclear weapons. Alternative methods for plutonium disposition exist, including the immobilisation of plutonium with highly radioactive waste in a matrix and its subsequent geological disposition; the 'dilute-and-dispose' option that would involve plutonium being mixed with an inert material and buried in an underground repository; or burial in deep bore holes.

It is important to emphasise that while declaring materials *excess to military use* and removing them from the weapons programme is a positive step from the point of view of disarmament and arms control, it is essential that the materials remains subject to the highest security standards afforded to materials in weapons during transfers, relocations, storage, and manipulations.[11] Overall, the lowest risk posed by materials declared excess is when the entire amount of the declared material is eliminated or transformed into non-weapons-usable form.

Facilities in the life cycle of military materials

As is the case with all nuclear materials and operations, the risk is usually the highest when materials are moving between processing stages or are in transit. Nuclear materials associated with military programmes are also vulnerable when they shift between the military and the civilian sectors, and when they are co-located in a facility used both for military and civilian applications (so called dual-use facilities). It is critical that the level of protection is harmonised according to the type of material, quantity, and dose regardless of whether it is under civilian, government contracted, or military control. In this section, we discuss some of the cases where military materials are processed at the same facilities as civilian materials or are co-located within a site. Some of these facilities have both civilian and military oversight or management; others have primarily civilian oversight and management while hosting both types of materials. The list is not complete, but is meant to highlight specific cases of dual-use facilities across the various stages of the nuclear fuel cycle stages. As demonstrated in the next section, some of these facilities have already experienced security breaches and thefts, and personnel from these facilities have had serious discipline and reliability issues.

Handling of Military and Civilian Materials by the Same Company

US naval reactors use fuel enriched to either 97% U-235 or 93% U-235. These fuels are fabricated by the company Babcock & Wilcox (BWXT), which owns and operates the only two commercial sites licensed by the US Nuclear Regulatory Commission to possess and process HEU. BWXT subsidiary Nuclear Fuel Services, located in Erwin, Tennessee, also manufactures fuel for six HEU-fuelled civilian high performance research reactors. Even though the areas of the facility may be separated between military and civilian uses of weapons grade material, the company appears to deal with weapons-usable materials for both civilian and military functions at its Erwin facility.

Dual-Use Weapons-Usable Material in the Same Facility

Before downblending or transfer of HEU to the BWXT Erwin facility, the US stores it at the HEU Materials Facility (HEUMF) at the Y-12 National Security Complex in Tennessee, which is managed by Consolidated Nuclear Security, LLC.[12] A security breach at Y-12 discussed later in this report has been well publicised, but the underlying causes of the breach—including the nature of the facility—have received far less recognition. The Y-12 facility is located on the campus of the Oak Ridge National Laboratory complex, which does not produce complete nuclear weapons. However, Y-12

produces and dismantles the 'secondaries', the source of the most powerful nuclear explosive for modern nuclear weapons for all US nuclear weapons, and stores enriched uranium in the HEUMF repository. The Y-12 facility also has distinct civilian roles, which are to provide HEU for high performance research reactors in Europe and the US, to provide HEU for medical isotope targets, and to store HEU declared excess to weapons use.

Facilities in other nuclear armed states also often handle both military and civilian materials. For example, the Mayak Production Association (MPA) in Russia is a vast dual-use nuclear facility covering an area of 200 km^2. The facility was responsible for manufacturing plutonium and HEU components for Russian nuclear weapons at least until 2014. MPA also reprocesses spent fuel from naval and research reactors. The reprocessing plant also processes spent fuel from domestic power reactors, such as VVER-440 types, and is expected to begin processing VVER-1000 fuel in 2017. The Mayak complex also stores separated plutonium from these operations.

In the 1990s, the US and Russia initiated a programme to downblend HEU from dismantled nuclear warheads and sell the LEU for nuclear power reactors. As part of the programme, HEU components from warheads were cut into shavings and converted to uranium oxide at the chemical metallurgical plant known as Plant 20 at Mayak and then transferred to uranium enrichment plants for downblending.[13]

MPA also operates the Mayak Fissile Material Storage Facility for weapons-origin nuclear materials, a large vault which could store 100 tonnes of plutonium or 400 tonnes of HEU and holds the material declared excess to military use.[14] Other Russian facilities, particularly uranium enrichment plants, historically were producing HEU for both military and civilian purposes until Russia stopped all production of HEU for weapons programme in the late 1980s.[15]

All five NPT NWS have reportedly ceased production of HEU for nuclear weapons purposes and have dedicated their enrichment plants to LEU production. They depend on previous stockpiles of HEU, largely accumulated during the Cold War, should they be required for naval fuel or weapons. In contrast, most, if not all, of the nuclear-armed states outside the NPT are still believed to be producing HEU and/or plutonium for weapons purposes to build up and maintain their arsenals.[16] The potential areas of overlap between civilian and military-use nuclear materials and facilities in India and Pakistan are highlighted below as examples.

Pakistan produces plutonium in four dedicated reactors at Khushab and reportedly has completed its Chashma reprocessing facility with significantly higher throughput compared to its two other reprocessing facilities at Rawalpindi.[17] The Chashma reprocessing facility for separating military plutonium is located within the same site, and close to, the civilian Chashma nuclear power complex, which has two 300 MWe reactors, with two others to be commissioned in the coming years.

India operates the Rattehalli Enrichment Plant (Rare Materials Plant) near Mysore as part of the Bhabha Atomic Research Centre (BARC) for the production of fuel for its nuclear-powered submarines and is thought to have also produced weapon-grade uranium for nuclear weapons.[18] India appears to be constructing another facility, known as the Special Materials Enrichment Facility, in the Chitradurga District at Karnataka that will be used both for military and civilian purposes. BARC officials have declared that the facility will not be under IAEA safeguards 'to keep options open for using it for multiple roles'.[19]

India also produces plutonium for both civilian and military purposes and has historically considered facilities that produce plutonium essentially as *dual-use* facilities. In fact, one of the reasons India chose to construct pressurised heavy water reactors was to be free from international pressure to curb plutonium production. Of its 20 such reactors, eight are not under IAEA safeguards, which gives India the option of using them to produce military plutonium, with an estimated capacity of up to 1250 kg/year.[20] Anil Kakodkar, Chairman of the Atomic Energy Commission and Secretary of the Department of Atomic Energy, admitted in an interview the importance of maintaining power reactors outside of IAEA safeguards in order to meet India's 'strategic need for plutonium.'[21]

There have not been any documented cases of HEU or plutonium theft from nuclear installations in South Asia. However, nuclear technicians and personnel

reportedly have been kidnapped for unclear motives.[22] Other reasons for concern are mentioned below. Pakistan's nuclear security practices have been praised by US officials.[23] However, given the sectarian violence and internal and external stresses present in the region, and especially in Pakistan, 'even the best nuclear security measures might break down', in the words of former White House official Gary Samore.[24]

As illustrated above, military weapons-usable material is regularly found at facilities with dual-use operations; where the material is directly used for civilian applications; or where other civilian activities occur, potentially leading to confusion in appropriate protection levels and protocols. The situation is further complicated when commercial entities are involved in handling and processing nuclear weapons-origin materials, sometimes at the same facility with civilian operations, potentially 'blurring the lines' between the civilian and military sectors.

The threat to weapons-usable material and facilities can come from insiders, outsiders, or insiders working with outsiders. The level of security must protect material from theft and facilities from sabotage in all scenarios. The security protocol for materials moving between the civilian and military sectors should not change unless weapons-usable materials are being converted to forms that are less attractive for use in a nuclear device. In sum, control and physical protection of such nuclear materials should be harmonised, so that they are applied consistently and the materials subject to the highest level of protection, whether they are in civilian or military control.

III. Security incidents at military and dual-use facilities

Incidents of theft, sabotage, security breaches, and personnel discipline and reliability problems at nuclear weapons sites and facilities that have both military and civilian missions have frequently come to public attention, highlighting the security risks that pertain to all nuclear materials. The incidents described below are neither exhaustive nor provided to highlight insecurities in specific countries. They are mentioned in order to demonstrate that both military and civilian HEU and plutonium are vulnerable in a variety of types of facilities. We also examine recent security cases involving civilian materials and facilities that point to new developments and vulnerabilities which could expose military materials to similar risks.

Military nuclear facilities

It is worth noting that the term 'military nuclear facilities' encompasses a wide range of facilities and sites. The term is used in this report to include such facilities as pulsed reactors under military control,[25] plants for producing naval propulsion fuel, storage sites for military HEU and plutonium (reserves and from retired warheads), assembly/disassembly facilities, and nuclear weapons and naval bases.

Given the importance attributed to national nuclear deterrence, military nuclear facilities are assumed to represent the pinnacle of security for militaries and for countries as a whole. Unfortunately, the main reassurances that nuclear-armed states provide are unsubstantiated assertions that we should simply take their 'solemn word for it'. This was the approach suggested, for example, by Lieutenant-General (Retired) Khalid Kidwai, who headed the organisation charged with controlling Pakistan's military nuclear programme.[26] Such reassurances are hardly reassuring, as every year we learn about vulnerabilities and breaches at military nuclear sites around the world despite the tendency to shroud incidents at military facilities in secrecy (especially outside the UK and the US). In light of the security problems that have emerged, the argument that military sites are adequately secured because they are protected by the military is not credible. Moreover, many facilities with military materials are in fact not protected by military officers, but by civilians.[27]

Military bases and vessels

Serious security lapses have taken place at facilities widely believed to be the most secure – nuclear weapons bases and nuclear-armed vessels. For instance, the US Air Force has experienced a series of scandals in recent years. In March 2016, 14 members of an Air Force unit at F.E. Warren Air Force Base in Cheyenne, Wyoming, responsible for guarding nuclear missiles were placed under investigation for possible illegal drug activity.[28] This followed a similar incident at Malmstrom Air Force Base in Montana where two nuclear missile launch officers were charged with illegal drug use.[29] The drug problem came to light following a separate investigation

into cheating on proficiency tests.[30] Unrelated to this, US nuclear missile launch officers in 2013 were found sleeping with a blast door open to their missile launch control capsule.[31]

As detailed in Eric Schlosser's book, *Command and Control*, and a 2014 Chatham House report, cases of inadequate security and dangerous close calls have been pervasive throughout the history of the US nuclear weapons programme.[32] In 2007, for example, six nuclear-armed cruise missiles at Minot Air Force Base in North Dakota were mistakenly loaded onto a B-52 bomber which sat unguarded overnight before flying 1,500 miles to a base in Louisiana where it was again left unguarded until a maintenance crew there realised the problem. The weapons were unguarded for a total of 36 hours.[33]

There have also been numerous concerns regarding US nuclear weapons stationed abroad. This issue is not new. A US Interagency Intelligence Memorandum from 1976, for example, suggested that nuclear weapons stationed in Europe could be targeted by terrorist organisations. It turned out that a significant number of the 4,800 nuclear weapons stored in the 123 NATO sites across Europe lacked 'Permissive Action Links', mechanisms designed to prevent unauthorised arming of a nuclear device.[34] Although there have been significant changes in security measures since the 1970s, a 2008 Air Force Blue Ribbon Review of Nuclear Weapons Policies and Procedures still echoed some of the concerns regarding nuclear weapons bases in Europe, stating that 'most sites require significant additional resources to meet DoD security requirements'.[35] The 15 July 2016 coup attempt in Turkey has heightened this concern. An estimated 50 B-61 nuclear bombs are located at Incirlik Air Base, from which tankers were launched to refuel the F-16s that bombed the Turkish parliament. In response, the government closed the airspace over the base, cut off its electricity and arrested the Turkish commander of the air base.[36]

This vulnerability of weapons storage facilities has been amplified by several high-profile incursions in the Netherlands and Belgium in recent years. The Belgian Kleine Brogel airbase, which hosts an estimated 20 US B-61 nuclear weapons,[37] has seen multiple forays by anti-nuclear activists who have gained access to protected areas surrounding hardened weapons storage bunkers. A group of peace activists was able not only to get into the base in February 2010, but also accessed the area where the hardened shelters containing the bombs were located.[38] This was followed later in the year by another unhindered visit to the same facility, captured on video and shared on YouTube.[39] Similarly, in 2014, four activists broke into Volkel Airbase in the Netherlands and posted pictures of shelters where US nuclear weapons were believed to be stored.[40]

Military facilities believed to be associated with Pakistan's nuclear weapons programme have also been attacked. These attacks included: assaults on an air force base thought to host nuclear-capable missiles in Sargodha in November 2007; an attack on the Minhas Air Force Base in December 2010; an attack in August 2008 by suicide bombers at a munitions factory in Wah – thought to be a key nuclear weapons assembly site – killing 70; and another attack at the Minhas Air Force Base in August 2012 involving eight militants wearing Pakistani military uniforms and armed with rocket-propelled grenades, explosive vests and automatic weapons. The attackers in these incidents never penetrated the interior of the bases and nuclear weapons appeared to be incidental to their motivations, but the attacks were seen as an indication of the danger of nuclear terrorism.[41]

In mid-2015, a Royal Navy submariner highlighted a number of security concerns relating to Great Britain's deterrent force. Able Seaman William McNeilly, 25, a newly qualified engineer, claimed that Britain's nuclear deterrent was a 'disaster waiting to happen' in a report published in *Guardian* detailing 30 alleged safety and security breaches. Saying his 19-page report was an effort 'to break down the false images of a perfect system that most people envisage exists', McNeilly described bags going unchecked at site entry points and said it was 'harder getting into most nightclubs' than into control rooms, with broken pin code systems and guards failing to check passes.[42]

The commander of the force that guards Russian nuclear weapons gave an interview to a Russian television station in October 2001 in which he spoke of two instances of terrorist groups carrying out surveillance at Russian nuclear weapon storage facilities. Speaking

to the channel ORT, General Igor Valynkin, who commanded the 12th Main Directorate of the Russian Ministry of Defence, described how the reconnaissance efforts had been 'nipped in the bud', and stated that no one had gained access to the weapons storage sites. However, the threat was deemed serious enough that Valynkin increased security at the warhead storage facilities, including additional guards with better equipment and training.[43]

Assembly, processing, and storage facilities

The British media reported in December 2013 that as many as 50 UK Defence Ministry law enforcement personnel were under investigation for allegations of sleeping on the job and not completing patrols at the Atomic Weapons Establishment in Aldermaston, Berkshire, the UK's primary site for constructing, maintaining, and disassembling nuclear warheads.[44]

Nuclear security concerns associated with the former Soviet Union in the early and mid-1990s are widely documented and include many cases of criminal activities by employees from nuclear facilities, drug and alcohol abuse problems, widespread corruption, and security regime breaches. A number of incidents involved nuclear weapons-usable materials originating from fuel fabrication facilities and reprocessing facilities with both military and civilian operations and materials present at their sites, as well as naval bases. These incidents represented troubling failures of nuclear security and triggered a broad spectrum of cooperative programmes to significantly upgrade the security and physical protection of these facilities.

Several incidents occurred after the upgrades, however, which suggests that additional quantities of HEU and plutonium may still be unaccounted for. Three cases of HEU seizures, in Bulgaria (1999), Paris (2001) and Chisinau, Moldova (2011), appear to have involved HEU reprocessed from spent fuel either from a research or naval reactor. They are among the 20-plus illicit trafficking cases involving HEU and plutonium that have been confirmed since 1993.[45] The packaging and attributes of the material in each of the three seizures suggest that it had been diverted from the same source or involved the same individuals. Recent reports allege that the seized material originated from the Russian nuclear facility at Mayak, which houses both weapons and civilian programmes and reprocesses both research and naval HEU fuel. The materials were thought to be samples for potential buyers of larger quantities of the material, but neither the size of the stolen stock of weapons-usable uranium nor its provenance is known.[46] It may not have been connected with these seizures, but in 1998, the Russian Federal Security Service uncovered and interdicted a plot involving 18.5 kg of HEU in the Chelyabinsk region, an area that houses one of Russia's nuclear weapons laboratories, the Mayak nuclear complex, an HEU enrichment facility and two nuclear weapons assembly and disassembly plants.[47] While it is not known which specific facility was involved, all of these facilities handle military materials of concern.

In perhaps the most widely reported incident of recent times, in July 2012, an 82-year-old nun and two other activists managed to gain access to the dual-use Y-12 Nuclear Security Complex in Oak Ridge, Tennessee. The facility, which is the central US repository for weapons-grade uranium, houses an estimated 400 tonnes of HEU and its security is said to be 'comparable to Fort Knox'. Yet the activists were able to cut through four high security fences and bypass faulty cameras en route to the HEUMF. Although the intruders were inside the Y-12 perimeter for around two hours, spray painting walls and hammering away concrete from guard towers, alarms were ignored by guards and it was not until the activists made enough noise to gain attention of workers inside the HEUMF facility that their incursion was noticed.[48]

The special investigation carried out by the Office of Audits and Inspections of the US Department of Energy (DOE)'s Office of Inspector General revealed that the Y-12 security incident 'represented multiple system failures on several levels' identifying 'troubling displays of ineptitude in responding to alarms, failures to maintain critical security equipment, overreliance on compensatory measures, misunderstanding of security protocols, poor communications, and weaknesses in contract and resource management'. This case highlights that complacency can occur even in the highest-security facilities.[49]

During the Cold War, Y-12's main role, in the words of a former US senior official, was 'producing the

components for vast numbers of thermonuclear warheads – [a role that] has largely vanished', although Y-12 is still involved on a smaller scale in providing the components for nuclear weapons as well as the fuel for naval and high performance research reactors.[50] Transitioning to a smaller role has been challenging, leading to neglect and complacency. It has been documented that 'containers with unstable and flammable forms of HEU sat for decades in hallways, narrow production aisles, and in process lines'. In addition, 'the exact content of numerous containers was not known, and many had never been opened'.[51] These aspects of neglect not only affect safety, but nuclear security as well, since the exact inventory is not known precisely, allowing thefts to occur undetected.

Naval bases and shipyards

The US and Russia both use vast quantities of HEU for naval propulsion, estimated at 40–60 tonnes for Russia and 90–100 tonnes for the US.[52] The UK also uses HEU for naval propulsion; estimates suggest that 7.2 tonnes is devoted to its Naval Nuclear Propulsion Programme.[53] In addition, the US considers its spent naval fuel (28 tonnes of 83% enriched spent naval fuel) as excess stocks eventually to be placed in a geological repository. Russian naval and research reactor spent HEU fuel is reprocessed at the RT-1 reprocessing plant at Mayak.[54]

Unlike the US, the Soviet Union and Russia used a variety of HEU fuel in naval reactor cores, with enrichment levels ranging from 20 to 90%.[55] Russia significantly downsized its submarine fleet at the end of the Cold War, retaining less than one-quarter of its ships, leaving a major environmental and proliferation concern as hundreds of reactors had to be maintained before decommissioning. Funding problems, as well as stricter environmental regulations, led to significant delays in decommissioning the reactors. The deteriorating conditions led to an urgent proliferation problem as nuclear materials in neglected reactors became vulnerable to theft. In 1993, two fresh fuel rods were stolen from a storage facility in Murmansk (Zapadnaya Litsa Naval Base) amounting to 1.8 kg of 36% HEU. Another case involved the theft of 4.5 kg of 20% enriched HEU extracted from three fuel rods at the Sevmorput Shipyard. The theft was noticed only because the back door of the storage area was left open. Following the theft, all fresh fuel stored there was consolidated to another location in Severomorsk.[56] Most of the perpetrators were naval officers or contractors working with the Russian Navy's Northern Fleet.[57]

North Korean 'agricultural workers' who were 'caught snooping around a Russian submarine base near Vladivostok' presented an even more serious proliferation issue. North Koreans were also detained for trying to persuade Russian naval personnel to sell them submarine dismantlement plans and the cruising schedules for operational nuclear submarines.[58]

Legacy effects of nuclear weapon programmes

The legacy of nuclear weapons programmes can present security risks, including from weapons-usable material that is outside military programmes and awaiting elimination. In November 2007, for example, four armed men penetrated the Pelindaba nuclear facility west of Pretoria. The site, home to South Africa's civilian nuclear research centre, stores between 400 and 800 kg of HEU from South Africa's former weapons programme.[59] Operating in two separate groups acting simultaneously, the attackers evaded high-voltage wires in fences, bypassed a magnetic anti-tampering mechanism, disabled alarms, cut the facility's communications and stormed the Emergency Operations Center at the complex, shooting one person.[60] They apparently had insider knowledge of the security system. The area storing the HEU was not breached and the motivations behind the attack remain unclear.

Legacy effects also include weapons that have been lost – so-called 'Broken Arrows' – as evidenced by incidents in Palomares, Spain, and Thule, Greenland, involving crashed US aircraft. Similarly, the effects of nuclear testing have left certain parts of the world vulnerable. The Soviet Union carried out 456 nuclear explosive tests during the Cold War at the Semipalatinsk Test Site in Kazakhstan. Some of these tests, especially those involving plutonium devices, left unvapourised material abandoned at the site, in forms accessible to those seeking to build a nuclear weapon. A report from Harvard University identifies that, between 1991 and 2012, scavengers in search of metal and equipment for

scrap were in close proximity to fissile material that had been abandoned and left unguarded. On two occasions, containers housing experiments were reportedly broken into, although there is no indication that plutonium was actually removed.[61]

Emerging threats

While peaceful protestors have carried out the majority of known incursions at nuclear weapons facilities, new threats involving unidentifiable perpetrators have begun to emerge. Flights over civilian nuclear facilities by drones and other unmanned aerial vehicles have become a frequent problem, particularly in France. As of 20 November 2015, drones of various sizes had made 32 flights above and around 14 nuclear reactor sites.[62]

In December 2014, computer systems at Korea Hydro and Nuclear Power Co Ltd, which runs South Korea's 23 nuclear reactors, were hacked and data was stolen and subsequently released on social media sites. The South Korean government concluded that North Korea was responsible, although Pyongyang denied any involvement.[63] The Stuxnet cyber worm attack on Iran's Natanz enrichment facility in 2009–10 was noteworthy for several reasons, not least because the facility was likely attacked on the assumption that the enrichment was for military purposes, although Iran claims it is entirely a civilian facility. The threat posed by cyber-attacks on civilian nuclear infrastructure has been the focus of increased scholarship.[64] The issue also featured prominently at the 2016 NSS, where improved cybersecurity at nuclear facilities was offered as a so-called 'gift basket' by 29 states and the UN.[65]

In August 2014 an unidentified worker sabotaged a turbine in the non-nuclear part of the Belgian Doel nuclear power station by draining its coolant. It was also revealed that another former Doel employee, Ilyass Boughalab who, in 2012, became a jihadi and went to fight in Syria, had been cleared for access to key areas of the facility and had been contracted to inspect welds between 2009 and 2012 before leaving.[66] Although insider protection regulations have been improved and armed guards now patrol nuclear facilities in Belgium, the terrorist attacks in Brussels in March 2016 have focused further attention on the threats to nuclear facilities. A suspect linked to the November 2015 Paris terrorist attacks was found with surveillance footage of a high-ranking Belgian nuclear official, raising fears of a larger nuclear-related plot.[67] In the wake of the Brussels attacks, authorities reportedly temporarily revoked the security clearances of several nuclear workers at the Tihange nuclear power plant.[68]

These cases highlight that even in a country with low perceived risks, vulnerabilities can be exploited; the highest level of security should therefore be afforded to the material inside and outside of weapons and to the facilities that handle it, regardless of their type and management. Security incidents have included theft and intrusion at a range of military and dual-use facilities, motivated by neglect, economic incentive, intentional malice or, in the case of the Y-12 incident, protest. A malevolent actor seeking nuclear materials for the purpose of using it in some sort of attack is unlikely to discriminate based on its nature. The difference between civil or military ownership therefore means little to a non-state actor; all sensitive nuclear materials must be protected to the highest standards, irrespective of origin or purpose.

IV. Legal and institutional framework

Despite the security vulnerabilities of all nuclear materials, the existing international nuclear security regime has largely focused on the small proportion of such materials in civilian use. Below we outline the instruments and institutions of the regime.

Legally binding international instruments

CPPNM

The Convention on the Physical Protection of Nuclear Material (CPPNM) was drafted under the auspices of the IAEA and entered into force in 1987. As of 15 September 2015, it had 153 Parties (152 states plus EURATOM. The CPPNM is an international treaty that requires states to apply a regime of physical protection to nuclear materials in peaceful uses while such material is undergoing international transport (during such times as this material is on their territories or on board their ships and aircraft travelling to or from their state). Broad physical protection requirements are specified in an annex. States are required to ban imports, exports, or transhipments of such material unless assurances are provided to them that the material will be transported under a regime of protection conforming to that specified in the annex. States are also required to criminalise certain acts involving nuclear material—including theft and threats of use to cause death and injury.

The CPPNM defines nuclear material as: 'plutonium except that with isotopic concentration exceeding 80% in plutonium-238; uranium-233; uranium enriched in the isotope 235 or 233; uranium containing the mixture of isotopes as occurring in nature other than in the form of ore or ore-residue;' or 'any material containing one or more of the foregoing'. Nuclear material used for military purposes is not addressed. Nonetheless, the preamble notes 'the importance of effective physical protection of nuclear material used for military purposes, and understanding that such material is and will continue to be accorded stringent physical protection.'[69]

CPPNM Amendment

In 2005, the text of an amendment to the CPPNM was adopted by consensus.[70] It entered into force on 8 May 2016 after the two-thirds ratification threshold was met. The title of the CPPNM was subsequently changed to the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities (CPPNMNF). The amendment modifies provisions of the convention and adds new language. Substantively, the amendment expands the application of the convention to include nuclear materials and nuclear facilities within states parties. It now includes an obligation to establish a national system of nuclear security covering all nuclear materials in use, storage and transport, whether domestic or international, and an obligation to protect nuclear facilities from sabotage. In addition, the list of malicious activities is expanded to include, inter alia, illegal transfers of nuclear material and sabotage of a nuclear facility, as well as the organisation of and or provision

of assistance in carrying out such acts. However, some provisions remain applicable only to nuclear material while in international transport.

Under the amendment, the preamble to the convention replaces the above referenced preambular paragraph on material in military purposes with the following:

> *RECOGNIZING also that effective physical protection of nuclear material and nuclear facilities used for military purposes is a responsibility of the State possessing such nuclear material and nuclear facilities, and understanding that such material and facilities are and will continue to be accorded stringent physical protection*.[71]

Unlike the original CPPNM, however, the amended Convention includes a provision (Article 2(5)) explicitly stating that it 'shall not apply to nuclear material used or retained for military purposes or to a nuclear facility containing such material'.[72]

ICSANT

The International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT) was adopted by the UN General Assembly in 2005 and entered into force in 2007. As of 29 March 2016, it had 103 states parties. ICSANT is an international treaty whose purpose is to contribute to the global legal architecture for the prevention, suppression and elimination of terrorism, in all its forms. ICSANT identifies specific acts involving nuclear and radioactive material as criminal offences, including the possession or use of radioactive material or devices to cause death, injury or damage, or to threaten such use. It requires states parties to adopt measures to establish such acts as criminal offences under domestic law and to make those offences 'punishable by appropriate penalties which take into account the grave nature of these offences.'[73] ICSANT does not differentiate between material in peaceful use and military use. Nowhere in the convention is either kind of material singled out for particular consideration.

Beijing Convention

The Convention on the Suppression of Unlawful Acts Relating to International Aviation—more commonly known as the Beijing Convention—was adopted in 2010 by the International Conference on Air Law, convened under the auspices of the International Civil Aviation Authority. The convention is not yet in force. Entry into force requires 22 states to ratify or otherwise accede to the convention. As of July 2016, only 14 had done so.

The Beijing Convention identifies as criminal offences certain uses of civilian aircraft for the purpose of causing death, serious injury or serious damage, including the use of civilian aircraft for the delivery of nuclear, chemical or biological weapons. States parties undertake to criminalise the unlawful transport of nuclear, chemical or biological weapons or related material. While there is no explicit exclusion of nuclear material in military use, the convention applies only to civilian aircraft, explicitly excluding 'aircraft used in military, customs or police services'.[74]

International Maritime Organization Conventions

SUA and SUA PROT

The Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation, more commonly known as 'SUA', was adopted at the 1988 International Maritime Organization (IMO) Conference. It entered into force in 1992. As of 8 March 2016, SUA had 166 states parties. SUA specifies as offences a range of acts against civilian ships, including seizure, destruction or other acts of violence. Under SUA, states parties are obliged to either extradite or prosecute alleged offenders. Neither SUA nor the related Protocol for the Suppression of Unlawful Acts against the Safety of Fixed Platforms located on the Continental Shelf (SUA PROT) include references to nuclear or radioactive material, nuclear facilities, or nuclear or radioactive devices.

SUA 2005 and SUA PROT 2005

In 2005, two protocols were adopted which expanded the scope of the original SUA and SUA PROT to include, inter alia, provisions relating to nuclear, chemical and biological weapons. The 2005 Protocol to SUA (SUA 2005) entered into force in 2010. As of 8 March 2016, it had 40 states parties. Under this protocol, it is an offence to transport 'radioactive material' on board a ship, knowing that it is intended to cause death or injury or to be used to compel a government or international organisation to take or not take any particular course

of action. It is also an offence to transport by ship any nuclear, biological or chemical weapon, or any 'nuclear source material' knowingly intended for use in explosive activities, or any related equipment knowingly to be used for the same ends. The protocol does not provide definitions for radioactive material, nuclear source material or nuclear weapons.

The 2005 Protocol to SUA PROT (SUA PROT 2005) also entered into force in 2010. As of 8 March 2016, it had 35 states parties. This protocol identifies additional offences, including the use against, or on, a fixed platform of any nuclear, chemical or biological weapon or any explosive radioactive material in a manner liable to cause death, serious injury or damage.

UN Security Council resolutions

UNSCR 1373

United Nations Security Council resolution 1373 (2001) was unanimously adopted following the 11 September 2001 terror attacks, and requires states to implement measures to enhance their legal and institutional ability to combat terrorist activities. These measures include: criminalisation of terrorist financing; prevention of terrorists receiving financial support; denial of safe havens for those who 'finance, plan, support, or commit terrorist acts'; and sharing information with other states.

Resolution 1373 does not focus specifically on nuclear or radiological material, but it does call upon states to 'find ways of intensifying and accelerating the exchange of operational information' on the threat posed by the possession of weapons of mass destruction by terrorist groups.[75] The resolution also 'notes with concern the close connection between international terrorism and transnational organised crime, illicit drugs, money-laundering, illegal arms trafficking, and the illegal movement of nuclear, chemical, biological and other potentially deadly materials'.[76]

UNSCR 1540

United Nations Security Council resolution 1540 (2004) obliges all UN member states to establish—if not already in place—appropriate and effective measures to prevent non-state actors from acquiring nuclear, chemical and biological weapons, as well as associated means of delivery and related items. Under resolution 1540, states are prohibited from providing any form of support to non-state actors seeking nuclear, chemical and biological weapons, and must also adopt and enforce laws prohibiting the manufacture, acquisition, possession, development, transport, transfer or use of such weapons.

Paragraph 3 of resolution 1540 requires states to 'take and enforce effective measures to establish domestic controls to prevent the proliferation of nuclear, chemical, or biological weapons and their means of delivery, including by establishing appropriate controls over related materials, including by putting in place 'appropriate effective' control measures to account for items and materials covered by the resolution, physically protect such items and materials, and prevent their trafficking. States must furthermore ensure that trade in such items and materials is properly managed and delivered only to responsible end-users. Paragraph 3 also requires states to develop and maintain border controls and export controls.

Resolution 1540 does not differentiate between materials used for civilian or military use. It refers to nuclear, chemical, and biological weapon 'related materials', which it defines as 'materials, equipment and technology covered by relevant multilateral treaties and arrangements, or included on national control lists, which could be used for the design, development, production or use of nuclear, chemical and biological weapons and their means of delivery'.

Under resolution 1540, a committee was established (the 1540 Committee)[77] to which states were called upon to provide an initial report within six months of the adoption of the resolution on 'steps they have taken or intend to take' to implement the resolution. In successive resolutions extending the mandate of the 1540 Committee, states which had submitted such reports were encouraged to provide, at any time and upon request of the 1540 Committee, further reports, periodically, on their implementation of resolution 1540. Guidelines issued by the 1540 Committee urge all states to report on 'steps they have taken or intend to take to implement the provisions of operative paragraphs 1, 2 and 3 of [resolution 1540]'. A total of 176 UN member states (plus the European Union) have now provided at least initial reports to the Committee.

Washington's detailed initial report to the 1540 Committee in 2004 noted that Department of Defense directives 'provide appropriate effective measures to account for and secure nuclear weapons and their means of delivery, storage or transport'. The report further noted the work of the US 'Nuclear Weapon Personnel Reliability Program' in ensuring that only trustworthy individuals, undergoing continuous evaluation, are allowed to perform duties associated with nuclear weapons. The transport of nuclear weapons, their components and 'other materials' was noted as being in the domain of the Department of Energy (DOE), using specially trained law enforcement personnel, dedicated government communications systems and specialised vehicles.[78]

In 2014 the United States provided a detailed 'matrix' report of its implementation actions under resolution 1540. These included, inter alia, DOE directives covering the physical protection of 'facilities, buildings, government property, employees, classified information, special nuclear material, and nuclear weapons, using a graded approach from lowest to most critical'.[79]

Each of the nuclear-armed states, except North Korea, has also submitted national reports on the implementation of resolution 1540, to varying levels of detail. China's fullest report was issued in 2004. It speaks of accounting and physical protection measures only in relation to civilian nuclear operations. However, there is a reference to the 'supervision and control of nuclear materials' designated under China's 1987 Regulations on the Control of Nuclear Materials. The report does not specify whether these regulations apply to civilian material only or to both civilian and military nuclear material.[80]

Russia's 2004 report to the 1540 Committee noted that nuclear materials were 'securely protected using modern technology', that the country was party to the CPPNM and that, in 1997, Russia approved a set of 'Rules for the Physical Protection of Nuclear Material Nuclear Devices and Nuclear Material Storage Facilities'. These rules, the report stated, were 'consistent with international recommendations on the physical protection of nuclear material'.[81] The report did not indicate whether it covered only nuclear materials in civilian use. A comprehensive English language legal 'matrix' provided by Russia to the 1540 Committee in 2014 identified the legislation and associated decrees relevant to the implementation of the resolution, without specifying further their applicability to civilian material, military material, or both.[82]

In reporting to the 1540 Committee in 2013, the UK noted that it 'applies the same rigour to enforcing compliance to prevent the theft or sabotage of non-civil nuclear materials as it does to the civil nuclear industry'. It noted that Ministry of Defence Police and British military personnel perform an equivalent role to Britain's Civil Nuclear Constabulary at military sites, and that 'non-civil site security is in line with guidance for the protection of civil material such as the IAEA Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5)'. In the context of non-civilian materials, the report further noted that the United Kingdom 'works closely with international partners to ensure the application of common international security standards, for example through joint security reviews and best practice exchanges'.[83] The US and UK held a meeting in August 2016 to discuss the physical security of nuclear weapons, for example.[84]

The initial report of France to the 1540 Committee noted that France based its physical protection system on the CPPNM, without indicating whether that went beyond application to civilian material only. The French report noted that 'all' French nuclear installations were considered as being of vital national importance, with operators subject to an array of obligations as to their protection, but did not specify whether 'all' refers only to civilian installations or includes military installations as well.[85] In its 2015 report, France refers specifically to civilian use nuclear material in the case of licensing, but does not otherwise make any such distinction.[86]

Among nuclear-armed non-NPT states, Pakistan's reporting to the 1540 Committee does not indicate whether there is a distinction between civilian and military activities. A 2008 update to Pakistan's 2004 initial report noted that Pakistan's nuclear regulatory body used IAEA document INFCIRC/225 as a 'guidance document' for 'the formulation of national regulations on nuclear security', but provided no indication as to whether this document, or the relevant regulations

based on it, were also being applied to nuclear material in military use.[87] The reports by India and Israel also do not make any explicit distinction between the application of their implementation actions under the resolution to nuclear material in civilian or military use.

In its 2015 report *The Results We Need in 2016: Policy Recommendations for the Nuclear Security Summit*, the Fissile Materials Working Group (FMWG) recommended further clarification of resolution 1540's call for appropriate effective security measures, and for states 'to commit to specific steps to achieve that standard in order to reduce the risk of theft'. The FMWG suggested that states 'commit to a rigorous threat assessment' and 'commit to recommended practices, such as defense in depth.' The FMWG also recommended that the five NPT NWS, referred to as the 'P5 States', develop a reporting form on military materials that could be submitted under UNSCR 1540.[88]

One of the five 'action plans' agreed at the 2016 NSS, focused heavily on boosting the implementation of resolution 1540, promoting, inter alia, stepped-up efforts to fully implement the nuclear security obligations of the resolution by 2021. It also called on states to make use of the opportunity offered by a comprehensive review of the resolution due to be carried out by December 2016 'to enhance its implementation and support of the 1540 Committee and its Group of Experts.'[89]

IAEA documents

Physical Protection Recommendations

The IAEA has developed several non-binding documents to assist states in building and maintaining appropriate levels of nuclear safety and security. While there are a number of technical documents, including fundamentals, and implementing guides, the most relevant set of these documents for our discussion is INFCIRC/225. The 1975 *Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities* (INFCIRC/225, subsequently revised five times) are designed to provide states with guidance on the development, implementation and maintenance of a physical protection regime for nuclear material and facilities. INFCIRC/225/Rev.5 makes clear that physical protection regimes are 'intended for all nuclear material in use and storage and during transport and for all nuclear facilities'. The document stipulates that the recommendations contained therein are specifically intended for the physical protection of civilian-use nuclear material and facilities, but that 'states may decide whether or not to extend the publication's use to other purposes.' [90]

Joint Statement on Strengthening Nuclear Security Implementation (INFCIRC/869)

At the 2014 NSS, 35 countries agreed to a 'Joint Statement on Strengthening Nuclear Security Implementation', pledging to take specific steps, 'at their own discretion, to meet the intent of the essential elements of a nuclear security regime and to commit to the effective and sustainable implementation of the principles therein'. The Netherlands, the host of the 2016 NSS, subsequently conveyed the Joint Statement to the IAEA, asking that it be published and inviting those states wishing to subscribe to it to inform the IAEA accordingly. As of May 2016, 38 states have subscribed to the Joint Statement, reproduced in IAEA document INFCIRC/869. In the Joint Statement, the subscribing states commit to:

- Subscribing to the fundamental principles ('Nuclear Security Fundamentals') set out in the IAEA's Nuclear Security Series, NSS 20 on the 'Objective and Essential Elements of a State's Nuclear Security Regime';
- Meeting the intent of the recommendations contained in:
  - NSS 13 (INFCIRC/225/Rev.5): the IAEA's 'Nuclear Security Recommendations on Physical Protection of Nuclear Materials and Nuclear Facilities'
  - NSS 14: the IAEA's 'Nuclear Security Recommendations on Radioactive Material and Associated Facilities' and its 'Code of Conduct on the Safety and Security of Radioactive Sources'; and
  - NSS 15: the IAEA's 'Nuclear Security Recommendations on Nuclear and Other Radioactive Material out of Regulatory Control'
- Continuing to improve the effectiveness of their nuclear security regimes and operators' systems, by conducting self-assessments, hosting periodic peer reviews (such as IPPAS reviews) and acting

upon any recommendations identified during such reviews; and

- Ensuring that management and personnel with accountability for nuclear security are demonstrably competent.

INFCIRC/869 also identifies a range of other measures designed to foster 'the continuous improvement of nuclear security', to some or all of which subscribing states agree to contribute. These include: the sharing of good practices and promotion of information exchange; the development of cyber defence measures for nuclear facilities; financial or in-kind contributions to the IAEA's Nuclear Security Fund; and the promotion of a nuclear security culture for staff involved with nuclear security. Notably, INFCIRC/869 does not specify whether the joint statement applies only to civilian nuclear materials or to all nuclear materials.[91]

Plutonium Management Guidelines

The Guidelines for the Management of Plutonium, reproduced in IAEA document INFCIRC/549 and agreed to by the five NPT NWS plus Belgium, Germany, Japan and Switzerland, sought to increase the transparency of the management of civilian plutonium through the publication of annual statements by each country of its holdings of such material.[92]

INFCIRC/549 provides information on the policies of the governments concerned with respect to the management of plutonium, and their 'continuing intention to ensure that holdings of plutonium under its jurisdiction, like those of other nuclear material, are managed safely and effectively in accordance with its international commitments and in ways which will reduce the risk of the proliferation of nuclear weapons and ensure the protection of workers, the general public and the environment'. The guidelines cover: separated plutonium; plutonium contained in unirradiated mixed oxide fuel elements; plutonium contained in other unirradiated fabricated goods; plutonium in the course of manufacture or fabrication; or plutonium contained in unirradiated goods being manufactured or fabricated. Explicitly excluded from the guidelines are the following: plutonium with an isotopic composition of plutonium-238 exceeding 80%; plutonium used in gram quantities or as a sensing component in instruments; plutonium exempted from IAEA safeguards; and plutonium on which IAEA safeguards have been terminated.[93]

Participating states report annually on quantities of material subject to the guidelines. INFCIRC/549 also includes the texts of notes verbales from each of the states concerned that indicate those aspects of the guidelines to which each of the states has chosen to adhere. Some of the addenda also include information on the strategy and or policy of the state concerned with respect to its nuclear fuel cycle and/or management of plutonium. For instance, in its November 1997 note verbale (published by the IAEA in 1998), the UK stated that: 'There is potential for reduction of military plutonium stockpiles by the recycling of plutonium, for peaceful use, within the safeguarded nuclear fuel cycle, as MOX fuel'.[94]

Although the guidelines do not explicitly address nuclear security, this is implied by the emphasis placed in them on responsible handling. The guidelines state that: 'Each State has an inalienable right to develop research, production and use of nuclear energy for peaceful purposes. This right is accompanied by sovereign responsibility for the use and management of all nuclear materials under its jurisdiction. Materials, however, which can be used for the manufacture of nuclear explosive components without transmutation or further enrichment are particularly sensitive and require special precautions.' The only specific instance in which INFCIRC/549 refers to security is in relation to where storage sites should be located. On this point, the guidelines note that: 'In authorizing storage sites, the Government of […] will bear in mind the desirability on security grounds of limiting the number of sites where such material is held.'

Political initiatives

Various political initiatives have also been pursued to progress and coordinate action on the security of nuclear materials and to provide information on the stocks.

Unilateral reporting

Although the Plutonium Management Guidelines do not apply to plutonium contained in spent fuel or to

HEU, they include a statement recognising 'the sensitivity of those materials and the need to manage them with the same sense of responsibility as the plutonium covered' by the guidelines.[95] With respect to HEU, the US in 2001 released details of its HEU inventory as of 30 September 1996.[96] The report had been commissioned to facilitate discussion of the storage, safety and security of HEU, and 'to encourage other nations to declassify and release similar data, and to support the national policy on transparency of nuclear materials'.[97] In March 2016, the US issued a fact sheet announcing the declassification and public release of data on the national inventory of HEU as of 30 September 2013. This fact sheet noted that the release of information represented 'an important part of the effort to strengthen global nuclear security'.[98]

In 2006, the UK Ministry of Defence declared its 'Total Audited Stock' of military HEU as of 2002.[99] The UK and France also annually declare their respective stockpiles of civilian HEU as part of their INFCIRC/549 declarations.

With respect to plutonium used for military purposes, in 2012 the US released its official report The United States Plutonium Balance, 1944–2009, updating a previous report on plutonium holdings released in 1996.[100] The UK declared the size of its stockpile of military-use plutonium, as of 1999, in its 2000 report Plutonium & Aldermaston: An Historical Account.[101] No other nuclear-weapon states or nuclear-armed states outside the NPT have declared stocks of HEU or plutonium in military use or the size of their overall stock of weapons-usable materials. Such declarations are more valuable to nuclear security, however, when accompanied by information about protective measures.

Nuclear Security Summits

From 2010 to 2016, four Nuclear Security Summits have been held to promote and coordinate international action on nuclear security. The summits emerged from US President Barack Obama's 2009 call in Prague for greater investment in securing nuclear materials around the world. Each summit resulted in the issuance of a communiqué identifying actions to be taken by participating states to further nuclear security. These communiqués are non-binding.

The first communiqué, issued in 2010, acknowledged the 'fundamental responsibility of States, consistent with their respective international obligations, to maintain effective security of all nuclear materials, which includes nuclear materials used in nuclear weapons, and nuclear facilities under their control'. It recognised that HEU and separated plutonium require special precautions and noted agreement among NSS-participating states 'to promote measures to secure, account for, and consolidate these materials'.[102]

The communiqués issued in 2012 and 2014 reiterated the responsibility of states to maintain security for all nuclear materials, including those in nuclear weapons, and again spoke of the need for special precautions to protect and control HEU and separated plutonium. The 2016 summit communiqué, however, dropped the reference to special precautions. None of the four NSS communiqués distinguished between civilian- and military-use nuclear materials in referring to the need to control HEU and plutonium.

It is important to note that all specific commitments contained in the summits' assorted mechanisms for deliverables (e.g. gift baskets and house gifts) have been targeted at civilian nuclear materials only. US efforts to build support for a joint statement on military materials at the 2016 summit proved unsuccessful.

As noted above, 38 countries have subscribed to the joint statement agreed to at the 2014 NSS and reproduced in INFCIRC/869. While the Joint Statement does not explicitly apply to military materials, neither does it explicitly exclude its application to such materials.

On its own initiative, the US has reported on the security of its military stockpile of materials. A 2016 White House fact sheet released on the eve of the summit noted that US 'security criteria and standards for protecting military materials and weapons in storage, use, and transport meet or exceed the recommendations for civilian nuclear materials contained in IAEA INFCIRC/225/Rev.5'. The fact sheet noted that, among other measures, the US 'maintains human reliability programs for personnel responsible for handling and securing military material' (including comprehensive screening and continuing evaluation), and that it 'routinely evaluates the effectiveness of security arrangements for military materials through a combination

of limited-scope performance tests, force-on-force exercises, engineering assessments, and other methods'.[103] The National Nuclear Security Administration (NNSA)'s Stockpile Stewardship and Management Plan went even further, voluntarily reporting on security provisions for military materials.[104]

The UK has also reported on security arrangements with respect to its military material. In its national statement to the 2016 NSS, the UK declared that:

> *'Our security arrangements are based on the principle of no unauthorised access, through the delivery of multi-layered, integrated, security arrangements designed to counter a range of threats and which are kept under review. Robust national security controls are applied to personnel responsible for, or who have access to, nuclear military material and associated information.'*

The UK further noted that:

> *'We have a well-established and on-going programme of activity to protect defence networks and the information they hold from cyber attack. And in addition to other security measures, we have strict accountancy and control measures for military nuclear material which are based on UK legislation and industry best practice.'*[105]

IAEA Ministerial Conferences and General Conferences

In July 2013, the IAEA convened an International Conference on Nuclear Security, attended by 34 government ministers among the 1,300 participants, in what was the first such occasion of its kind at the IAEA. The conference was intended as a forum for experiences and lessons to be shared, and for identifying emerging trends in nuclear security.

The conference resulted in a Ministerial Declaration, which, much like the NSS communiqués, affirmed 'the fundamental responsibility of states, consistent with their respective national and international obligations, to maintain effective security of *all* nuclear materials under their control, which includes nuclear materials for military purposes' [emphasis added].[106] A second IAEA Ministerial Conference on nuclear security is to be held in December 2016.

The security of 'all' nuclear materials has also appeared in recent resolutions on nuclear security debated at the annual IAEA General Conference. In 2015 and 2014, the nuclear security resolutions included an identical preambular paragraph:

> *Asserting that the responsibility for nuclear security within a State rests entirely with that State, and mindful of the responsibilities of every Member State, in accordance with its respective national and international obligations, to maintain effective nuclear security of all nuclear radioactive material.*

In 2013, the nuclear security resolution adopted by the IAEA General Conference included similar language. All three resolutions refer to the role of the IAEA only in relation to civilian nuclear materials, however.

In 2015, the IAEA General Conference Nuclear Security resolution also featured for the first time a paragraph on disarmament that stirred heated debate:

> *Recognizing that nuclear security contributes to the broader goal of strengthening international peace and security, and stressing that further progress is urgently needed in nuclear disarmament, consistent with relevant international nuclear disarmament and non-proliferation obligations and commitments.*

This language, proposed by Switzerland, was based on the rationale 'that nuclear security should not be addressed in isolation or limited to physical protection but should be viewed as an integral component of international peace and security' by linking it to disarmament and nonproliferation.[107] In the view of the NPT NWS, however, the conflation of nuclear security, which is necessary in its own right, with a call for further progress on nuclear disarmament represents an unwelcome and inappropriate development. It is a controversy that highlights the difficulty of addressing military stocks of material, from the point of view of security, while keeping it divorced from the far more politically contentious arena of disarmament in negotiating fora such as the IAEA General Conference.

At the 2016 NSS, the action plan released in support of the IAEA advocated both for the IAEA 'to support

States' efforts to keep their stockpiles of separated plutonium to the minimum level, consistent with their national requirements' and for it to 'expand efforts to facilitate the removal and disposition of nuclear materials from facilities no longer using them'.[108] The reference to 'national requirements' could be interpreted as referring to defence as well as civilian needs, although the plan itself is ambiguous about this. The call for expanded IAEA efforts to facilitate disposal of excess material is, for its part, reminiscent of the 2000 Russia–US Plutonium Management and Disposition Agreement.

Global Partnership

The Global Partnership Against the Spread of Weapons of Mass Destruction was initiated at the 2002 G8 Summit to run as a ten-year effort to prevent terrorist acquisition of nuclear, chemical or biological weapons. In 2011, the Global Partnership was extended beyond 2012. No new end date for the partnership was specified at its extension.

The partnership currently involves 28 participating states. In its first ten years, it was principally focused on projects in Russia and other states of the former Soviet Union. Between 2002 and 2011, major achievements of the partnership included: the destruction of approximately 20,000 tonnes of chemical weapons; the dismantling of decommissioned nuclear-powered submarines; improvements in the detection of nuclear and radiological materials; re-employment of former weapons scientists and technicians in civilian programmes; and consolidation of 775 bombs' worth of nuclear materials in secure storage in Kazakhstan.

In 2011, the Global Partnership agreed to focus its future work on four priority areas: nuclear security; biological security; scientist engagement in the field of weapons of mass destruction; and implementation of UN Security Council resolution 1540. The 'Action Plan for Support of the Global Partnership' released as part of the 2016 Nuclear Security Summit identifies a number of areas where, with a view to enhancing 'national nuclear security regimes', the partnership is seeking to develop its activities and which have applicability across the civilian–military divide. These include efforts to provide assistance to, and coordinate, programmes and activities on, inter alia: nuclear security culture and personnel reliability; the reduction of insider threats; and the transportation of nuclear materials. None are specified as being directed toward either the civilian or military realm.[109]

GICNT

The Global Initiative to Combat Nuclear Terrorism (GICNT), co-chaired by the US and Russia, was launched in 2006 and currently consists of 86 partner states and, as official observers, five international organisations.[110] All five NPT NWS are GICNT partners, as are India, Pakistan and Israel. Partner states commit to implementing GICNT's 'Statement of Principles', a set of eight nuclear security goals focused on establishing and improving states' own capacities to prevent, detect and respond to nuclear terrorism.

Three of these principles are relevant to the issue at hand. The first is that partner states commit to '[d]evelop, if necessary, and improve accounting, control and physical protection systems for nuclear and other radioactive materials and substances'. The second relevant principle commits partners to '[i]mprove capabilities of participants to search for, confiscate, and establish safe control over unlawfully held nuclear or other radioactive materials and substances or devices using them'. Neither principle specifies that the 'nuclear and radioactive materials and substances' in question are limited to civilian or military use. The third relevant principle commits states to enhance security of civilian nuclear facilities.[111] The work of the GICNT is primarily conducted in three working groups: nuclear detection; nuclear forensics; and response and mitigation. There is currently no working group under GICNT dedicated to improving the protection of nuclear materials.

It should be noted that the terms of reference for the GICNT exclude military programmes from its scope: 'None of the activities of the Initiative involves the military nuclear programs of the nuclear weapon states party to the Treaty on the Nonproliferation of Nuclear Weapons.'[112] As former White House official William Tobey notes, however, officials from military programmes have often attended GICNT meetings.[113] Given the precedent of the participation of the military in the early meetings of the GICNT, nothing in the terms

of reference or the statement of principles prevents an expanded and regular participation of military representatives in the GICNT.

The Action Plan in Support of the Global Initiative to Combat Nuclear Terrorism released at the 2016 NSS identified a range of nuclear security-related measures that partner states agreed to pursue, including advocacy for GICNT activities promoting capacity building 'across the spectrum of nuclear security challenges', and the promotion of understanding of 'critical technical concepts and sharing models for practical implementation of important nuclear security concepts', to improve technical capacity in partner states.[114] While these action plan points suggest a possible widening of focus for the GICNT over the coming years, the plan does not specify whether these recommendations are aimed at civilian or military nuclear materials and facilities.

P5 Process

In 2009, the five NPT NWS initiated what became known as the P5 Process to discuss implementation of nuclear disarmament obligations.[115] The main result of this process to date has been the publication of a *P5 Glossary of Key Nuclear Terms*, promoted as a way of contributing to transparency in line with the Action Plan of the 2010 NPT Review Conference Final Document. The process has not addressed nuclear security or the control of nuclear materials, whether in peaceful or military use, despite a section on nuclear safety and security in the aforementioned glossary.

In its 2015 report, the FMWG recommended that the P5 states either establish a forum on nuclear materials security, 'or incorporate a nuclear materials security agenda into an existing forum like the P5 Process'.[116] The FMWG called on the P5 to '[e]stablish a working group on security of nuclear weapons and related nuclear military materials with a mandate to share information and best practices'. The group suggested that such a group 'could review past successful bilateral and multilateral cooperation to inform future practices'.[117] The FMWG also called for nuclear security terminology to be included in ongoing work on the P5 Glossary.

Short of collective action by the whole P5, the FMWG suggested that a 'P3' group of France, the UK and the US 'could take initial steps to begin addressing the security of military nuclear materials'. The group noted that such a group 'could lay a foundation for further progress in the P5 and eventually all states with such materials'.[118]

NTI-Proposed Military Nuclear Materials Working Group

In 2015, NTI suggested that countries with military nuclear materials should establish a 'multilateral technical-level working group' that could 'provide a forum for communication between representatives of organisations responsible for the security of military materials in each of these countries'. Such a group, NTI suggested, 'would allow these organisations to exchange best practices, conduct training exercises, and share lessons learned related to military materials security'.[119] It is worth stressing that countries with military materials extend beyond the P5 group of states. A group of this kind could, for instance, be conceived of as a 'P5+2' arrangement, bringing in the declared nuclear-armed, non-NPT states of India and Pakistan.

V. Policy recommendations

Our research indicates that advancing international oversight for the security of *all* nuclear materials, particularly the bulk of material lying outside civilian control, will be a highly challenging endeavour in the post-NSS environment. Most importantly, political and legal realities will limit the role that can be played by the IAEA when it comes to the security of military material. Despite the Agency's central importance to international nuclear security, its ability to go beyond recommendations and offers of voluntary assistance is constrained even with respect to the security of civilian materials and facilities. Thus, it is not likely to serve as the institutional home for such discussions. The current opposition of some key countries to even discussing the issue of military materials is likely to limit the ability to use other fora as well, including the United Nations.

For the time being, a three-pronged approach by supportive states makes the most sense. **One approach** would seek to advance efforts in existing multilateral fora which do not explicitly distinguish between civilian and military nuclear materials: these include inter alia, the United Nations (the Security Council and the General Assembly), and the Global Partnership. Specific means include resolutions by the UN General Assembly and/or Security Council, full implementation of UNSCR 1540 and the publication of relevant information into national reports. It could also involve the inclusion of military experts into cooperative projects, exercises, training, and sharing of best practices under the Global Partnership and the GICNT. The 2016 NSS Action Plans with respect to the latter two initiatives include items that span the civilian military divide and present opportunities for work to be carried out in such a fashion.

The second approach would seek to extend to all nuclear materials existing mechanisms, including those within the IAEA framework as well as NSS commitments and other initiatives, that currently apply only to civilian materials. A particularly useful route in this regard may be through the Contact Group established by some of the NSS participants to continue to push the outcomes of the Security Summit process, especially in IAEA fora such as the annual General Conference and ministerial conferences on nuclear security. IAEA member states could also individually and collectively promote voluntary application of the IAEA recommendations and guides to all nuclear materials. Since 2013, member states have started including the security of all nuclear materials, including in weapons programmes, into the IAEA GC resolutions on nuclear security and are pressing to include them in the final declaration of the ministerial conference. IAEA member states should continue including reference to the responsibility of states 'to maintain effective nuclear security of *all* [italics added] nuclear and other radioactive material' and 'at all stages in their life cycle' in key IAEA resolutions and declarations on nuclear security. Likewise, supportive states could work to include a panel or side event on military nuclear materials during the upcoming IAEA

ministerial conference on nuclear security. Such a panel or event could feature speakers from any and or all of the nuclear-armed states and result in commitments to extend some IAEA standards to all nuclear materials.

Although GICNT excludes military programmes from its terms of reference, an expanded and regular participation of military representatives in its meetings would contribute to sharing of the best practices and procedures. It would also assist in building working relationships and coordination among civilian and military experts.

The third approach would be to establish new forums or to make use of existing technical or working-level efforts among all of the nuclear-armed states, or initially a sub-group of them, to advance best practices and norms in this area. A US–UK bilateral meeting focused on the physical security of nuclear weapons is a good demonstration of such activity.[120]

Substantively, the recommendations under the three-pronged approach fall into four groups: a) minimisation, elimination, and consolidation; b) voluntary application of at least civilian standards to *all* nuclear materials; c) exercises, training, and sharing of best practices; and d) transparency and reporting.

Minimisation, elimination, and consolidation

The most direct way to limit the threat that fissile materials could fall into the wrong hands is to limit the amount of such materials. Eliminating excess military nuclear materials presents technical, economic, and political challenges. While HEU downblending is relatively straightforward technically, it can entail economic and political challenges. Plutonium disposition is more complicated than HEU downblending because plutonium of any grade can be used for a nuclear weapon and none of the options for disposition completely denature the plutonium. In addition, plutonium is often seen as potential fuel for reactors, rather than as material that needs to be disposed of for environmental, safety and proliferation reasons. Treating excess plutonium as an asset rather than as a liability could increase the possibility of theft of the material as the barriers between military and civilian use are decreased and the material is distributed to more sites.

Efforts to minimise the use of HEU in civilian applications have been underway since the late 1970s, particularly programmes to convert research reactors to LEU. In the past ten to 15 years, broad consensus has emerged regarding the desirability of phasing out and eliminating the use of HEU in the civilian sector. The NSS process gave a significant boost to the repatriation of HEU, the conversion of research reactors and medical isotope production reactors and targets, and the downblending of the HEU to LEU. Nevertheless, there is still no universal commitment to these goals, and the various political documents that address this issue still call only for voluntary efforts, even more so when the discussion touches upon the inclusion of non-civilian materials.

As noted above in this report, at the 2016 NSS, the Obama Administration opened a door to a new means of significantly cutting military (though not weapon use) HEU stocks by endorsing research on the use of LEU in naval reactors. About one-sixth of all fissile materials—an amount equivalent to all civilian materials—is dedicated to naval use worldwide and, as noted above, some of the most publicised episodes of nuclear smuggling involved such materials. Any US actions in this regard would certainly affect the closely tied UK nuclear navy. France and China currently use only LEU fuel, while Russia relies on HEU. Brazil, a non-nuclear-armed state, has yet to rule out the use of HEU for nuclear submarines it is building with French assistance (for the non-nuclear parts of the vessel). In 2014, the US Office of Naval Reactors indicated for the first time that 'it might be possible over 20 to 25 years to develop LEU fuel for US naval propulsion reactors'. This would not only decrease the threat posed by theft of the fuels themselves, but also allow for the potential downblending of 140 tonnes of HEU currently set aside for future naval use.[121]

The viability of LEU for naval fuel might make an appropriate subject, perhaps for France, to raise in the P5 conferences and meetings, as well as within the HEU minimisation discussions in the NPT context. This would be a good topic for a technical working group, for diplomatic discussions, and for Track 1.5 or Track 2 fora.

Efforts to minimise and eliminate separated plutonium have been far less successful. As noted

above in Section III, the major international effort to address stocks of military plutonium—the Russia–US Plutonium Management and Disposition Agreement—has been stalled by political and cost disputes. Getting the agreement to dispose of the officially declared 34 tonnes of surplus plutonium by each side back on track could provide some inherent nuclear security benefits.[122] But drawing down military stocks of plutonium could be more important for other reasons: one would be to provide an example for holders of civilian plutonium to do more to draw down those stocks; the other would be to establish the IAEA's role in accounting for and monitoring such activities, building on the legacy of the Trilateral Initiative and PMDA transparency consultations.

Efforts to eliminate HEU and to minimise HEU and separated plutonium could be supported broadly through a United Nations General Assembly resolution. Such a resolution could echo the 2010 NPT Review Conference Action Plan Action item 16, which calls for the NWS to put under IAEA verification all nuclear material no longer needed for military purposes and also include a pledge to eliminate these materials.[123] Future NPT preparatory committee meetings and review conferences should continue pushing for these commitments as well. Putting a similarly structured commitment in the form of a stand-alone General Assembly resolution would have an additional benefit of extending this effort to non-NPT parties and providing an important global imprimatur.

Voluntarily applying civilian standards to all nuclear materials

The effort during the NSS process to make detailed IAEA guidance on nuclear security the baseline for states' nuclear security laws and regulations offers another route for progress. In the NSS context, pledges by countries to adhere to IAEA guidance (such as the pledges made in the Strengthening Nuclear Security Implementation Initiative – INFCIRC/869) were limited to or intended for civilian nuclear materials. Ideally, the pledges should treat IAEA guidance and principles as the floor rather than a ceiling. The INFCIRC/869 initiative has now been endorsed by all of the nuclear-armed states (including Israel) except for North Korea, Pakistan, and Russia. Although the IAEA's nuclear security publications are written with a view to their application to nuclear materials in civilian use, all those that address aspects of securing nuclear materials are equally relevant as a starting point for securing such materials in the military realm. IAEA recommendations and guidelines with respect to security in connection with civilian nuclear materials could also be applied to nuclear materials in military use, if a state decided to utilise them in that way. INFCIRC/225/Rev.5, explicitly notes that the recommendations contained therein, while intended for civilian use, can be used for 'other purposes'.

The United States voluntarily reported in 2016 that its military nuclear materials are secured with measures that either 'meet or exceed' the recommendations of INFCIRC/225/Rev.5. Other nuclear-armed states could also pledge to apply to military materials the full slate of guidance and recommendations set out in the IAEA's Nuclear Security Series to military materials. There is no national security reason not to do so.[124]

Supportive states could also consider a role for the IAEA in advising them whether their military nuclear security regulations conform to IAEA standards, akin to the role that it already performs for civilian facilities. INFCIRC/869's call for peer reviews is generally interpreted to refer to International Physical Protection Advisory Service (IPPAS) missions. However, some states believe it would be difficult to apply IPPAS missions to military-use material and sites due to classification concerns. Even in the civilian sector, some states are reluctant to accept IAEA missions or other forms of peer review on the basis that nuclear security is solely the responsibility of the state. Going a step further and applying IPPAS missions to the non-civilian sector would, therefore, likely encounter resistance. It should be recognised, however, that peer reviews can also take other forms. In addition to IPPAS missions, the IAEA offers Nuclear Security Advisory Services, which assess regulations and legislation, rather than particular arrangements at specific locations. If even hosting such IAEA services seems a step too far, such a task could be delegated to a 'trusted agent', defined by the NTI report as 'someone from a host state or a trusted ally of a host state, who, by force of scientific

reputation, standing, and training in security matters, could be relied on to ensure the adequacy of the host state's security'.[125]

Supportive states could consider making pledges to extend two of the elements of the civilian HEU minimisation gift basket for the 2016 NSS to military materials. One pledge was, 'where practicable, to convert or shut down all HEU reactors', including pulsed reactors. As noted above, most pulsed reactors are actually in the military sector, and should also be shut down. Although Russia still has several pulsed reactors in military use, the US is looking to shut down its last military pulsed reactor.[126] The second pledge, implicitly supporting efforts to minimise military nuclear materials, was to 'continue to identify additional HEU stocks to be declared excess and downblended'. This promise could be made more explicit.

Additionally, states could use a future CPPNMNF review conference to extend its provisions to materials beyond the civilian sector. The convention is limited to material in peaceful uses and, in its amended form, makes explicit the exclusion of military nuclear materials from its scope. Nonetheless, both versions of the convention recognise the importance of 'stringent' physical protection for such materials, if only in the preamble. Further amendment of the CPPNMNF to extend its provisions to materials in non-civilian use theoretically could be pursued, but political hurdles and the inevitably protracted nature of negotiations on any such amendment make this option highly unrealistic for the foreseeable future. That the importance of proper security for military nuclear materials is acknowledged in the CPPNMNF does, however, point to a possible avenue ahead: the use of voluntary mechanisms by nuclear-armed states to report on actions taken to secure military nuclear materials.

Exercises, training, and sharing of best practices

More could be done to build on the hands-on experience derived from previous efforts, such as the US–Russian 'Nunn–Lugar' programmes and various bilateral and trilateral exchanges of best practices (e.g. the exchange carried out by the US, the UK and France in 2014). Such exchanges should continue, ideally along the lines of the US–UK–Russia exchanges but at least among countries with existing relations of trust.

The NTI report referred to above included a particularly useful recommendation on training exercises and demonstrations:

> Countries could conduct training exercises related to military materials security, inviting participants from countries with military materials and countries without military materials as observers. Countries could also conduct joint exercises with other countries. These activities could include tabletop exercises, demonstrations, and technical exchanges. Country representatives also could use such opportunities to facilitate best practice exchanges and classroom exercises related to physical protection and material control and accounting.[127]

GICNT might represent one particularly useful vehicle for such exercises, given its joint US and Russian leadership. In fact, the practices exercised in its working groups to address missing nuclear materials are just as applicable to nuclear materials in military use as to nuclear materials in civilian use, notwithstanding the Terms of Reference limitation noted above. Given that national militaries are likely to have some role in many of these situations, one initial step could be to involve military representatives and defence officials in such meetings and exercises.

Similarly, supportive states could seek to have the Global Partnership involve military officials responsible for nuclear security in programmes funded by the partnership that are applicable to all nuclear materials. A process of certification that such military officers have been adequately trained in nuclear security would also build confidence in the security of all nuclear materials. The nuclear security Centres of Excellence in several of the nuclear-armed states (China, India, Pakistan, Russia, and the US) might serve as a means of providing such validation, and provide platforms for sharing best practices. The World Institute for Nuclear Security (WINS) Academy might also be considered for this purpose, although to date WINS has focused exclusively on the civilian sector.

Separately, the P5 Process presents a pre-existing forum in which the security of military nuclear materials could be addressed as part of a new, distinct thread of discussion among the NWS. The P5 Process could provide a useful forum for the discussion of greater transparency among the five with regard to the publication of information on the compliance of their military materials and sites with IAEA guidelines and principles for nuclear material security.

To offset political concerns about the potential for linkages to be drawn between nuclear security and disarmament, the NTI-proposed model of an entirely stand-alone grouping could also be pursued. This might include the convening of a process of dialogue involving technical representatives from some or all of the NPT NWS and from some or all of the declared nuclear-armed states outside the NPT. Participating states could share information on security measures for nuclear materials and make collective decisions as to what information might be published, in the form of joint statements, for the purposes of wider international reassurance, much as was done with the Plutonium Management Guidelines. Other topics that might be considered for discussion and information sharing include emergency measures and notifications in the event of an incident at sites housing military use nuclear materials.

Reporting and transparency

The NTI report on the security of military materials pointed to several different kinds of reports that nuclear-armed states could make to the international community to provide greater confidence that they are securing all nuclear materials, including material in non-civilian use: declarations of aggregate data; publication of the results of accident and security incident investigations; and reporting of military material security regulations.[128] The simplest venue for such reporting would appear to be reports on the implementation of UN Security Council Resolution 1540. Reporting under resolution 1540 is not verified and thus has limits as a confidence-building measure. However, such reporting can contribute to transparency.

A stand-alone group of experts, as discussed above, could be another mechanism for focusing on the development of reporting parameters and possible validation measures.

The CPPNMNF could also be used for such reporting. Following the 8 May 2016 entry into force of the amendment to the convention, there have been suggestions that future review conferences could be used to discuss the security of all nuclear materials. The CPPNMNF represents the most viable instrument under which to pursue future strengthening of security for all nuclear materials. Interviews carried out under this project, and the convention's negotiating history, indicate, however, that it will be difficult to win sufficient political support for legally binding measures on military materials akin to those that the convention requires for civilian stocks.

Still, some progress is possible by making use of Article 14 of the CPPNMNF, which requires state parties to inform each other of their laws and regulations which give effect to the convention. An analogy can be drawn to reporting on nuclear safety. Nuclear safety has evolved over time from being viewed as an issue for each state to manage in its own way (in much the same way as nuclear security is treated today) to a matter of global concern requiring coordinated action. The regime of conventions that underpin global nuclear safety[129] make use of voluntary reporting by states above and beyond that which is required by the letter of the instruments in question. An example of this is the Convention on Early Notification of a Nuclear Accident, with respect to which each of the five NWS indicated in 1986 that they would provide voluntary notification of accidents taking place outside the civilian scope of the Convention.[130] This serves as a precedent for states party to a civilian-focused nuclear security convention to report on parallel activities in the military realm.

In relation to the IAEA, the CPPNMNF review process represents the most viable instrument under which to pursue future such reporting and other measures to strengthen the security for *all* nuclear materials. Nuclear-weapon possessors that are parties to the convention, whether amended or un-amended, could be encouraged to report voluntarily on the extent to which their security of military nuclear materials is in conformity with the convention. In this way, they would be able to demonstrate that they hold their

military nuclear material security to at least the same level as that required by the CPPNMNF for civilian stocks.[131]

Nuclear-armed states could choose, individually or collectively, to publish information about their non-civilian plutonium holdings.

At the 2016 NSS, Norway proposed to establish a voluntary reporting mechanism through the IAEA to track states' progress on civilian HEU removal, downblending, disposition, and stocks. Norway is drafting a template for such reporting and could include the option of reporting on *all* HEU holdings, not just civilian ones. Such further reporting would complement steps already taken elsewhere by the US and the UK.

Reporting of all nuclear material stocks within the NPT review process is another option. However, it has the drawback of not including non-NPT parties.

Outside of existing reporting channels, recognition could be given to unilateral commitments, such as those laid out in French President Sarkozy's 2008 Cherbourg speech and China's statements on minimum credible deterrence and 'no first use'.[132] Despite their non-verifiability, such commitments may be the best window of opportunity for getting to the issue of accountability and providing the basis for improved assurance. Unilateral reports on HEU and plutonium holdings published by the US and the UK have already set a precedent for such reporting and should be followed by all states with nuclear weapons programmes. For transparency about the stockpiles to truly contribute to confidence in adequate security, however, these reports should also be accompanied by information on the security systems and measures applied to all weapons-usable materials, including military materials.

Addendum: Non-proliferation and disarmament benefits of strengthening security of *all* weapons-usable nuclear materials

Nuclear security is not a substitute for non-proliferation or disarmament, nor is it directly linked to non-proliferation and disarmament efforts. It can, however, both benefit from and contribute to each of these goals in a number of ways.

An analogy with safety helps explain the role and place of nuclear security in the context of non-proliferation and disarmament. Like nuclear security, nuclear safety is not a non-proliferation or disarmament measure. The safety of nuclear materials and installations is expected to be maintained at all times. Both nuclear safety and security ensure that nuclear materials in use, storage, or transport, and nuclear facilities, do not harm humans or the environment, whether by accident or malice. Any disarmament or non-proliferation benefits derived from nuclear safety and nuclear security measures are a positive externality. Such measures also contribute to greater transparency and the building of trust in dealing with a host of nuclear governance issues if they involve bilateral or multilateral verification or monitoring components. The reverse is also true.

There have been a number of non-proliferation and disarmament initiatives that have had a positive impact on nuclear security. For example, in the late 1970s, the United States launched a programme to convert research reactors it had previously supplied to other countries from HEU to LEU fuel. These efforts were driven by proliferation concerns after India's 'peaceful' nuclear test in 1974. In the early 2000s, concerns about nuclear terrorism were the primary motive behind the accelerated reactor conversion efforts and the repatriation and downblending of HEU from the reactors. Regardless of the motive, in the end, the conversion of the reactors and the elimination of HEU benefited both nuclear security and non-proliferation interests, as these efforts eliminated the very material that can be used, whether by a state or by a non-state actor, for weapons purposes.

There are other examples of arms control, non-proliferation, and disarmament efforts contributing to nuclear security. For example, in the early 1990s, the United States and Russia agreed to eliminate HEU from their respective dismantled nuclear warheads by downblending the HEU to LEU. The primary motivation for this effort was to make the reduction of nuclear weapons irreversible. The downblending efforts also contributed, however, to lowering the risk of nuclear terrorism and strengthening nuclear security by reducing the overall stocks of weapons-usable materials. It is useful to note that the HEU–LEU programme in Russia was governed by an agreement between the United States and Russia that involved transparency monitoring measures to ensure that, in Russia's case, at a minimum: a) the material involved had come from dismantled nuclear warheads; and b) the HEU removed from weapons was indeed downblended to LEU. Monitoring under the HEU–LEU programme targeted key industrial processes, areas, and data that did not involve the disclosure of nuclear weapon design or other sensitive

information, but was still indicative of the declared processes and operations, and satisfied both sides.[133] The elimination of some of the excess US HEU stocks was conducted under IAEA verification.[134]

The transparency arrangements under the HEU–LEU programme clearly demonstrated that when parties are interested in achieving common goals they can find means to manage access to some of the most sensitive facilities and processes in order to accommodate the other side's need for information, while building trust that the agreement is being implemented properly. These arrangements, and their implementation, serve as valuable experience for verification of future nuclear disarmament agreements. Similarly, they show that there are ways of providing transparency and accountability useful for ensuring the security of non-civilian nuclear materials, even in the absence of disarmament or non-proliferation measures.

As demonstrated by the two examples above, nuclear risk reduction efforts can reduce more than one type of risk; non-proliferation, arms control, and disarmament efforts can overlap and be mutually beneficial. For example, a robust nuclear material accounting system is the cornerstone of the international safeguards system (and thus has direct bearing on non-proliferation). At the same time, a national nuclear material accounting and control system, albeit established for different purposes, is a key component of a comprehensive nuclear security infrastructure and helps to deter and detect insiders' illegal acquisition of such material. A robust accounting and control system is also essential for disarmament efforts. For example, the availability of well-maintained accounting records in South Africa was critical for reconstructing that country's production of nuclear materials for its weapons programme and later enabled accounting for the nuclear materials from the dismantled nuclear warheads.[135]

From a variety of national and international efforts aimed at nuclear security and nuclear terrorism risk reduction, a number of principles and good practices have emerged over the last 25 years. Three relevant lessons stand out:

- Consolidation of nuclear materials and nuclear sites is one of the principles and objectives in lowering nuclear security risks. The reduction and minimisation of the number of sites and the amount of nuclear materials in use or storage allows a state to focus on better security for fewer locations through a more efficient use of human, technical, financial, and other resources. Consolidation and minimisation of materials goes hand in hand with the elimination of nuclear materials that are no longer needed, including excess HEU and plutonium released from military programmes and other non-civilian applications.
- Comprehensive security of nuclear materials and facilities includes not only the physical protection of sites and materials, but a robust material accounting and control system that is capable of deterring and, if necessary, detecting the diversion of nuclear materials.
- The development of tools, procedures, and modalities for joint risk reduction programmes, peer reviews, collective nuclear security exercises, and other joint nuclear security efforts facilitates the effective implementation of such activities and builds trust among the participating parties.

These nuclear security principles and practices also are of benefit to non-proliferation and disarmament goals. One of the most obvious benefits is the minimisation and elimination of weapons-usable nuclear materials. The elimination of surplus civilian and military HEU and plutonium denies the availability of such materials to states and to non-state actors. Comprehensive and unequivocal commitments to the minimisation and elimination of weapons-usable materials by all states possessing them would greatly benefit nuclear security, non-proliferation and disarmament.

Accountancy and control of nuclear materials at the national level, and transparency about stocks under a nuclear security framework, would be useful for establishing baselines for any future FMCT, as a foundation for verifying compliance under an FMCT or other treaties concerning stocks of HEU and plutonium.

For many years, a number of non-governmental and governmental experts have been promoting universal reporting of civilian and non-civilian stocks by all countries that possess such materials. The current Guidelines

for the Management of Plutonium (IAEA INFCIRC/549) do not require reporting on non-civilian stocks. Nevertheless, the US and the UK report their holdings of both civilian and non-civilian-use plutonium, either through special national reports or in the context of reporting under the guidelines. They and France have also released details on national HEU inventories. While such reports are voluntary and are not subject to international verification, they create a basis for establishing a norm or instituting a 'good practice' for transparency and accountability, especially when accompanied by information about security measures.

Earlier this century, the US and France promoted the adoption of HEU transparency guidelines that included not only the reporting of HEU stocks and their minimisation, but also recommendations for nuclear security, as well as proposals for putting civilian HEU stocks under IAEA safeguards. The possibility of adopting HEU guidelines was explored again early in the NSS process. However, the effort did not secure consensus support.[136]

The idea of HEU management guidelines or some similar instrument (such as an HEU code of conduct) need not be foreclosed and could be pursued within other fora, including at a 2018 HEU Minimization Conference announced by Norway at the 2016 NSS. It could also be pursued through the establishment of a dedicated group of international experts representing countries with HEU holdings. At the 2016 NSS, Norway also proposed to establish a voluntary reporting mechanism for countries with HEU – through the IAEA – to track states' progress on civilian HEU removals, down-blending, disposition, and stocks.[137] Whether through this new initiative, HEU management guidelines, or other mechanisms, such reporting would benefit all major nuclear regimes: nuclear security, non-proliferation and disarmament. It is highly desirable, however, that both civilian and non-civilian materials be included and that additional significant quantities of military stocks be declared excess and slated for disposition and elimination.

Another initiative that could have had an overarching benefit for all three regimes is the US–Russia–IAEA Trilateral Initiative pursued between 1996 and 2002 that envisioned the two countries placing excess military nuclear materials under IAEA verification. Unfortunately, despite addressing the relevant technical, financial, and legal instruments for plutonium, the initiative fell apart when new presidents who did not feel vested in the initiative came to power in the US and Russia.[138] However, the results of the Trilateral Initiative could still be used by other countries wishing to place excess military stocks of nuclear materials under IAEA verification (for example, the United Kingdom). Such an initiative would facilitate the irreversible removal of excess stocks from national military stocks, placing them under the IAEA verification as the first step and then eliminating these materials altogether.

The transparency of holdings of fissile materials and international monitoring of excess materials has been pursued within the NPT review process for over 15 years. In fact, the Trilateral Initiative was one of the 13 practical steps agreed upon in 2000 at the NPT Review Conference. Ever since, calls for the transparency of stocks and the implementation of the Trilateral Initiative have remained on the agenda of the NPT, but have not been implemented. While the US and the UK have provided reports on their weapons-usable materials, other countries, particularly those with growing nuclear arsenals, are not likely to report their stocks. While some countries, most notably Russia, may have difficulty in providing a sufficiently comprehensive and complete report of their holdings. In Russia, these challenges arise as a result of changes in the accounting system and the difficulty of establishing an accurate and complete physical inventory and accounting for past production due to irregular and poor accounting practices in the early and mid-1990s following the break-up of the Soviet Union.

The availability and accuracy of inventories, and records of past production, are key to ensuring that no nuclear material is allowed to fall into the wrong hands. After all, the majority of the HEU and plutonium stolen in the 1990s, smuggled out of facilities, and subsequently seized by police or discovered by accident, was never reported missing from facilities in the first place. A robust accounting for and control of stocks is a cornerstone of the nuclear security regime. A published record and periodic updates of these inventories could provide reassurance to the international community

that possessors of such materials are taking the security of their stocks seriously and, in particular, that irregularities and unnoticed loss of materials, as happened in Russia in the 1990s, are not repeated. As noted above, these records and reports would be invaluable to FMCT implementation and verification and, ultimately, for disarmament. Confidence in disarmament efforts, particularly at lower numbers of weapons, would rely not only on the elimination of warheads, but on the accounting for and eventual elimination of fissile materials from the warheads, to prevent reconstitution.

Ultimately, the reduction and eventual elimination of nuclear security risks can only be assured through the reduction and subsequent elimination of weapons-usable nuclear materials in both civilian and non-civilian use, and the nuclear weapons themselves. As long as these materials and weapons exist, the need for ensuring their security remains high throughout all stages of production, use, storage, and elimination of weapons-usable materials, regardless of their classification as civilian or military.

Strengthening the security of military materials does not necessarily have a direct impact on disarmament – nuclear security needs to be addressed in any event, whether disarmament moves ahead or the current deadlock continues. Yet many existing and future nuclear security efforts that involve civilian and non-civilian materials have the potential for providing a constructive and concrete contribution to future disarmament efforts.

Notes

1 John P. Holdren, *Management and disposition of excess weapons plutonium: reactor-related options* (National Academies Press, 1995), p.12.

2 The quoted language is from 2015 IAEA General Conference resolution on nuclear security, GC(59)/RES/10, available at https://www.iaea.org/About/Policy/GC/GC59/GC59Resolutions/English/gc59res-10_en.pdf.

3 National Nuclear Security Administration, 'Fiscal Year 2017 Stockpile Stewardship and Management Plan – Biennial Plan Summary', March 2016, https://nnsa.energy.gov/sites/default/files/nnsa/inlinefiles/FY17SSMP%20Final_033116.pdf. See pp. 3-20 to 3-28.

4 The United States and the United Kingdom were the only states that provided information on the security of military nuclear materials at the 2016 Nuclear Security Summit. While the information provided is limited, particularly in the UK case, this is a welcome development. This practice should be expanded to include all states with nuclear weapons programmes.

5 Andrew Bieniawski, Des Browne, Richard G. Lugar and Sam Nunn, 'Bridging the Military Nuclear Materials Gap', Nuclear Threat Initiative, 10 November 2015, p. 9, http://www.nti.org/analysis/reports/bridging-military-nuclear-materials-gap/.

6 National Nuclear Security Administration, 'Nuclear Security Focus of U.S., Russia, and U.K. Workshop', press release, 16 October 2009, https://nnsa.energy.gov/mediaroom/pressreleases/10.16.09; National Nuclear Security Administration, 'NNSA, Rosatom, UK Ministry of Defence Hold Trilateral Nuclear Security Best Practices Workshop', press release, 19 November 2013, https://nnsa.energy.gov/mediaroom/pressreleases/trilat.

7 Mark Fitzpatrick and Elena Sokova, 'Why the world needs better nuclear security, World Economic Forum, 6 February 2015, https://www.weforum.org/agenda/2015/02/why-the-world-needs-better-nuclear-security/; Mark Fitzpatrick and Elena Sokova, 'How can we push for tighter security for nuclear weapons?, World Economic Forum, 2 June 2015, https://www.weforum.org/agenda/2015/06/how-can-we-make-our-nuclear-weapons-more-secure/.

8 Russia reportedly has downblended 513.2 tonnes HEU in both weapons and non-weapons HEU. The United States has a dynamic stock of material that it has declared excess. In 1994 it declared 174.3 tonnes HEU excess to military needs which it increased to 235 tonnes in 2009 including commercial, naval reactor spent fuel, and low equity discards. Since 2009, this quantity has increased by another 4 tonnes to a total of 239 tonnes HEU. Of the latter quantity, 146 tonnes have been downblended leaving another 93 tonnes in the stockpile. David Albright and Serena Kelleher-Vergantini, 'Military Highly Enriched Uranium and Plutonium Stocks in Acknowledged Nuclear Weapon States; End of 2014', 3 November 2015, https://isis-online.org/uploads/isis-reports/documents/Military_HEU_and_Pu_Stocks_in_Acknowledged_NWS_November3_2015_Final.pdf.

9 Fuel that has not been irradiated should have a higher security level because the fuel does not carry a radiation dose that might deter would-be thieves. International Atomic Energy Agency, Nuclear security recommendations on physical protection of

nuclear material and nuclear facilities (INFCIRC/225/Revision 5). IAEA Nuclear Security Series No. 13, 2011, www-pub.iaea.org/MTCD/publications/PDF/Pub1481_web.pdf.

10 A US Department of Energy document entitled 'Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material' concluded that 'Virtually any combination of plutonium isotopes – the different forms of an element having different numbers of neutrons in their nuclei – can be used to make a nuclear weapon. Not all combinations, however, are equally convenient or efficient'. For this reason, the IAEA in their safeguards assessment has attributed the same level of physical protection to all forms of plutonium. The only exception is when the plutonium-238 concentration exceeds 80%, which produces a great deal of heat, making it difficult to construct a nuclear weapon. It is challenging, however, to assemble sufficiently large quantities of plutonium-238 to enable denatured plutonium mixtures. W.E. Bickford, 'Large scale production of Pu-238 to denature weapons-grade plutonium', 2 December 1996, Westinghouse Savannah River Co., Aiken, SC.

11 The 1994 National Academies Report on the disposition of plutonium described the 'Stored Weapons Standard' which is directly applicable to military-origin nuclear materials. It argues that 'stringent standard of security and accounting must be maintained throughout the disposition process, approximating as closely as practicable the security and accounting applied to intact nuclear weapons.' The study also urges that this 'stored weapons standard' should 'become a standard for protecting comparable materials in civilian use throughout the world'.

12 'Y-12 National Security Complex', http://www.y12.doe.gov/.

13 http://fissilematerials.org/library/rr07.pdf.

14 http://www.washingtonpost.com/wp-dyn/content/article/2007/08/31/AR2007083102125.html.

15 Russia, however, since 2012 has initiated the production of HEU through enrichment at the Zelenogorsk Electrochemical plant (EKhZ) (formerly known as Krasnoyarsk-45). While it did not re-start the production of HEU for weapons programme, it produces weapons-usable HEU for Russian ice breakers and fast reactors, as well as HEU for foreign high performance research reactors like the FRM-II in Germany.

16 International Panel on Fissile Materials 'Global Fissile Material Report 2015 – Nuclear Weapon and Fissile Material Stockpiles and Production', 2015, http://fissilematerials.org/library/gfmr15.pdf.

17 David Albright and Serena Kelleher-Vergantini, 'Pakistan's Chashma Plutonium Separation Plant: Possibly Operational', *Institute for Science and International Security*, 20 February 2015, available at http://isis-online.org/uploads/isis-reports/documents/Chashma_February_20_2015_Final.pdf.

18 India has developed two nuclear powered submarines (INS-Arihant and INS- Aridaman), and is working on a third and a fourth one.

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