Disruptive, Destabilising, and Dual-Use: The Proliferation Risks of 3-D Printing

Additive manufacturing (AM), colloquially characterised as 3-D printing, has the potential to revolutionise the global supply chain. The ability to print near-finished items and machine components at the site of intended use could drastically lower financial, technical and distribution barriers to production as AM technology spreads across the globe.

AM is an exciting technological disruptor, having already demonstrated its applicability to a number of major industries, perhaps most notably to health care, where scientists Murphy & Atala note that '3-D bioprinting' of human tissue and bone is currently making significant strides. However, AM is a dual-use technology, with the potential to be applied for illegitimate, non-peaceful or malicious intent. For example, it is possible that AM printers could be used to manufacture conventional weapons and sensitive components for gas centrifuges and uranium hexafluoride (UF6) processing facilities, enabling the circumvention of current export control regimes.

This article addresses the inherent security concerns of additive manufacturing. Firstly, it identifies how AM's unique production method could enable the proliferation of sensitive components for both conventional weapons and nuclear reprocessing technologies. Secondly, it outlines how AM technology offers aspiring proliferators a way around the restrictions of the dual-use technology regulatory regimes. Thirdly, it explores the potential pathways for controlling AM systems, drawing on the recommendations of technical experts. Finally, it offers a reason for optimism, ultimately asserting that the same traits which en-

In this issue

Trust & Verify
Summer 2017 • Issue Number 157 • ISSN 0966–9221

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able AM to be a proliferation risk may also allow it to play a constructive role in the verification and monitoring processes. In this unique way, AM is a paragon of dual-use technology.

The Proliferation Risks of AM

AM is a system of production by which three-dimensional objects are created by fusing together stacked layers of material, under direction from digital modelling software. The raw materials used in production could include polymers, organics, ceramics, and even metals, of which the latter is typically manufactured by applying and melting layers of metal powder onto a moving building platform. The additive process allows for minute customisation of complex items without yielding significant waste. This contrasts with the more traditional process of subtractive manufacturing, which creates objects by removing excess material from a larger block.

Relative to subtractive manufacturing, AM is low-cost, low-waste, low-signature and low-skill. These four characteristics carry an inherent degree of proliferation risk. Sophisticated, industrial AM printers can be purchased for approximately $1 million, and the associated raw materials used in production for only thousands of dollars more. Neither states nor malicious non-state actors fixated on conventional or nuclear proliferation would baulk at this price tag, and prices are expected to fall as the technology matures. Additionally, the raw materials themselves last much longer in AM than in more wasteful forms of subtractive manufacturing, as the additive process allows for a much greater degree of cost efficiency. As noted in a formative 2015 paper by Matthew Kroenig & Tristan Volpe, the lack of excess material generated by AM is also an important component of its low-signature nature, supplementing the fact that a sophisticated AM printer is approximately the size of a commercial fridge, and does not use much energy. 'In an AM factory,' as Marco Fey additionally suggests in a 2017 paper for the Peace Research Institute Frankfurt (PRIF), 'it is less obvious what is actually being built in comparison to a factory with subtractive tools, where casting molds or special tools are being used.' Finally, the AM process is designed to reduce tacit knowledge barriers of production, and although technical expertise is still necessary to produce complex components that are fit-for-purpose, Grant Christopher argues in the Autumn 2015 issue of Strategic Trade Review that the requisite knowledge is increasingly becoming available to determined proliferators.

This is not to suggest that AM invites the danger of printing nuclear warhead components or fissile material, and extensive technical studies by Robert Kelley and Grant Christopher have rebutted some of the more sensationalist claims that 3-D printing 'could trigger World War 3.' However, Robert Kelley has noted in a SIPRI study that there remains justified apprehension over the potential for AM to facilitate the production of ancillary components for gas centrifuges and industrial nuclear facilities, such as valve bodies, seats, bellows and shafts. He has highlighted that printing powders made from Inconel (a type of nickel alloy) and maraging steel are of particular concern, as the former can be used in specialised UF6 pressure gauges, and the latter can be used in centrifuge endcaps, baffles and rotors—all of which are necessary for nuclear weapons production.

The impact of AM on conventional weapons proliferation is already evident. Using commercially-available 3-D printers, Raytheon researchers claim to have printed 80% of the parts necessary for a guided missile, including rocket engines, fins, and guidance components. Additionally—and disturbingly, from a proliferation standpoint—the digital build file for the first 3-D printed gun was downloaded over 100,000 times before the US State Department demanded that the production company, Defense Distributed, remove it from its website for apparent violation of the International Traffic in Arms Regulations (ITAR) regime.

Circumventing the Regulatory Framework

The international regulatory framework for dual-use technology transfers consists of a patchwork of politically-binding Multilateral Export Control Regimes (MECRs), and legally-binding instruments such as UN Security Council Resolution 1540 (2004) on the non-proliferation of weapons of mass destruction, their delivery systems and related materials. States have disparate national export control systems, reflecting their varying participation in the MECRs or acceptance of MECR guidelines. Across UN member states the implementation status of international legal obligations, in particular UNSCR 1540, is similarly varied. The United States, for example, adopted the International Traffic in Arms Regulations (ITAR)

in 1976, pursuant to its Arms Export Control Act, as a unilateral control system for defence and military technologies, in order to buttress the multilateral regime enacted by the Coordinating Committee for Multilateral Export Controls (COCOM), which targeted the Soviet bloc. After the Cold War ended, COCOM member states acknowledged the need for a new series of export control arrangements to address the spread of conventional and dual-use technologies. This recognition led to the adoption of the Wassenaar Arrangement (WA) MECR.

While AM technology predates most of the MECRs, the weapons proliferation risks of AM only became apparent after the MECRs—which focus on technologies and materials associated with subtractive forms of production—were developed. As such, several notable loopholes remain within the international control regime which could be exploited by proliferators using AM. For example, Grant Christopher has identified that while maraging steel is subject to regulation under the Missile Technology Control Regime (MTCR) (6.C.8) and the Nuclear Suppliers Group (NSG) (2.C.11), maraging steel powder, which can be used to 3-D print maraging steel items, is not. Robert Kelley doubts that 3-D printed maraging steel could currently be used to manufacture critical gas centrifuge components, given concerns over its ability to match the strength of its conventionally-produced counterpart; however, as Christopher asserts, 'challenges to producing 3D printed maraging steel with properties comparable to traditionally manufactured maraging steel are being gradually overcome.' He takes care to note that these barriers are being weakened not by the introduction of new printing technologies, but rather through collective learning of how to use the incumbent AM systems to reach a higher degree of precision. Therefore, Christopher acknowledges that 'it is entirely conceivable that the current generation of 3D printers could be used to manufacture key components of one of the sensitive and controlled technologies in the nuclear fuel cycle.'

Bolstering this assessment, the German AM company EOS recently claimed to have printed items from maraging steel powder which matched tensile strengths of 2050MPa±100MPa after age hardening, which as Marco Fey notes, is nearly identical to conventionally manufactured maraging steel parts. Fey also identifies four 'revolutionary materials'—graphene, amorphous metals, carbon fibre, and boron nitride nanotubes (BNNT)—which could all be produced with AM and carry additional proliferation potential.

Manufacturing capabilities aside, AM poses significant challenges for verification and monitoring. As the name suggests, export control regimes require the ability to track shipments. As Kroenig & Volpe note, with AM 'there is no need to ship and store parts and virtually no waste; the end user can just download the digital file and print the component whenever and wherever it is needed.' For example, Robert Kelley asserts that present export controls for a highly proliferation-sensitive absolute pressure transducer used to measure UF6 pressure (3.A.7 of NSG) could be subverted by printing its Inconel-based diaphragm at the site of intended use. Inconel powder is not subject to any export controls under the MECRs, nor is any 3-D printing hardware. Marco Fey also identifies a scenario in which a proliferator could 'lease export controlled components for gas centrifuges… disassemble them, use a sophisticated 3D scanner to obtain all necessary design information… and then transform the design data into build files for the 3D printer.' This would reduce the need for proliferators to rely upon illegal procurement and smuggling networks, thus complicating the efforts of intelligence agencies and law enforcement.

Patching the International Controls Regime

The MECRs are political arrangements, not legal ones. They do not contain binding enforcement clauses, instead deferring to national legislation which is informed by the guidelines drafted by the MECR participants. However, a lack of binding enforcement mechanisms does not hinder regulatory efforts: participating states have a vested interest in matching their national policies to the MECR guidelines in order to prevent the proliferation of destabilising technologies. Therefore, the best way of closing these loopholes would be to update the existing MECRs in order to accommodate for AM technologies, thus precipitating a trickle-down effect into the national policies of the participating states and, ideally, other states which draw on these guidelines as effective practice.

The MECRs provide not only sound regulatory guidance for

strengthening national control regimes, but they also contain formal mechanisms which can be used to catalyse updates to the arrangements. For example, the Experts Group is a subsidiary entity of the Wassenaar Arrangement Plenary—the decision-making body of the WA—which meets on an ad-hoc basis to discuss the control list and address recommendations for potential additions. Similarly, the NSG has a Technical Experts Group charged with ensuring that the control lists are 'complete and up-to-date with technical advancements.' Experts have pointed to several measures which could be explored by these groups to strengthen existing export controls and offer new pathways for verification and monitoring of AM technologies and materials.

A clear first step would be to establish controls for the printers themselves; however, the key to an effective dual-use control mechanism is that it must not simultaneously prohibit or unnecessarily restrict the peaceful use of this technology. Grant Christopher has drawn up a list of specifications for those 3-D printers which would be capable of manufacturing maraging steel, based upon the number of axes, the build volume, and the ability to operate in an inert atmosphere, among other technical qualities. As Christopher notes, the EOS M series, the Matsuura Lumex Avance-25, Renishaw AM250, SLM 280 or SML 500 and Concept Laser machines all meet the specific criteria for printing maraging steel and should therefore be controlled. These are all expensive and highly-advanced models, thus control measures would not impact the majority of commercially available 3-D printers. It would also be prudent to keep track of printer exports with an ID verification system that establishes legitimate end-use and end-user controls.

The metallic powders associated with the 3-D printing of sensitive materials should also be subject to regulation. As noted by Grant Christopher, maraging steel powder has the same chemical composition as its controlled traditional counterpart (US 18% Ni Maraging 300, European 1.2709 and German X3NiCoMoTi 18-9-5), yet the powder form is absent from the MECR control lists. This should just be a matter of a simple update.

Another possible regulatory measure would be to control the digital build files which direct the Computer Aided Design (CAD) software in printing sensitive components. As previously mentioned, the US State Department required that Defense Distributed remove the CAD files for its 3-D printed gun from its website, as their distribution violated ITAR. However, while a CAD file for a gun clearly deserves a place on a regulatory munitions list, Christopher notes that CAD files for rotors or endcaps constitute relatively simple geometries (in addition to having numerous peaceful applications) and are therefore impractical to control. This being said, sensitive CAD files with complicated geometries should be controlled when possible, and multilateral steps should be taken to secure all CAD build files from cyber threats. Kroenig & Volpe offer some creative advice for embedding safeguards directly into the CAD files themselves: potentially compartmentalising critical data across several build files, or perhaps developing digital files that would corrupt themselves upon completion of pre-programmed tasks, to prevent misuse. Marco Fey also notes that the security of CAD files in transport could be bolstered through the proven application of blockchain technology—essentially, an incorruptible, transparent cyber-ledger which enables secure online transactions.

Printing the Positive

There is an optimistic flip-side to the AM issue: the same inherent characteristics which allow AM technology to be a proliferation risk also create an opportunity for it to play a constructive role in the international nuclear verification regime. As noted previously, AM is low-cost, low-waste, low-signature and low-skill, compared to traditional methods of subtractive manufacturing. These traits apply equally to components in weapons systems as they do to components in verification equipment.

Of particular note is AM's unique ability to print 'anything, anywhere,' streamlining the costly, shipping-based supply chain. As Fey notes, this is already being put to use in conflict and disaster zones and even in space, with NASA intending to begin printing replacement parts on the International Space Station using a 3-D printer sent up in March 2016. The same methods can be applied to on-site IAEA inspections.

When conducting such inspections, Vincent Fournier notes that IAEA technicians often use three to five pieces of equipment which sometimes need to be shipped to the destination

ahead of time. Verification equipment can also be very expensive; as Alain Lebrun, Head of the IAEA Non Destructive Assay Section, explains, 'some of these tools cost more than a sports car,' and most inspection equipment has a lifespan of only ten years. In an effort to improve both inspection accuracy and long-term equipment viability, and reduce verification costs, the IAEA notes that it strives to keep up-to-date with technological innovations.

AM could provide a way for the IAEA to strengthen its inspection capabilities. The ability to manufacture low-cost, lighter-weight detection tools on-site would greatly reduce shipping costs and inspection timelines. This equipment would be easily replicable and highly customisable; as noted in a 2012 National Defense University briefing report, with regards to AM, 'complexity is 'free'." One of the greatest strengths of AM lies in its efficacy as a prototyping tool, as minute customisation procedures at each layer cost nothing, and components can be produced in lot sizes of one to allow for continued upgrades as technology advances. Inspection authorities would therefore not be wedded to large batches of outdated technology for sunk cost purposes, instead, new equipment could be developed on an ad-hoc and cost-effective basis. Additionally, AM could serve to increase the limited lifespan of verification equipment, as it allows for on-site repairs and individual part replacements. As well, the AM process generally contributes to a greater understanding of why things break and encourages creativity in 'designing out' these flaws.

In a response to Kroenig & Volpe's article, Amy Nelson asserts that the AM loopholes are a symptom of a much greater malady, that 'the combination of innovation and digitisation causes our existing controls and regimes to fail.' However, in this case, it is worth it to lightly push back against passivity: innovation does not kill arms control regimes—it challenges them, as it should. The structure of the existing dual-use controls regime has a solid foundation; it just needs a renovation. As Marco Fey notes, it is fortunate that the majority of the countries with strategic AM production industries—Australia, Germany, Japan, South Africa, South Korea, the UK, and the USA—are also participants in the MECRs. As such, building upon these incumbent arrangements could result in a strengthened controls regime which lowers the financial, technical and efficiency barriers to verification inspections. It is just a matter of acknowledging the risks, consulting with relevant stakeholders, and above all, finding the political will to rise to the challenge.

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Maintaining strategic stability with the development of Conventional Prompt Global Strike systems

A little over six months into the new Trump administration, the US Department of Defense (DOD) has yet to unveil its plans for the future of the development of Conventional Prompt Global Strike (CPGS) technology. Originally begun under the George W. Bush administration, the CPGS programme was identified as a way to fulfil what was termed the 'prompt global strike' mission by the DOD. The goal of this mission was to provide the United States the ability to strike targets around the world in as little as one hour or less without needing to rely on forward deployed forces. The rationale that supported and continues to support the pursuit of such a programme is that such capabilities would provide the US the ability to quickly target and strike high-value and/or highly-mobile targets, such as terror network cells, in a short amount of time without needing to use forward based forces. Such a programme has been earmarked as providing a niche capability that while not a silver bullet for every instance that may need forward deployed forces, would be valuable for US strategic military planning.

Proponents have argued such capabilities will bolster deterrence and have also sold it in such a way that may remind students of history of the policy of 'flexible response'. CPGS supporters argue that having this tool in the defence arsenal increases the range of options available to the President since at this current point in time, the only missiles that are capable of travelling such distances and striking as deeply into an enemy's territory so quickly without being forward deployed are nuclear armed intercontinental ballistic missiles. By developing conventionally armed long-range missiles, the US would then have the ability to conduct strikes on targets that previously may have been inaccessible to US forces due to anti-access and area denial capabilities, or on targets that could only have been successfully destroyed with nuclear use due to their 'hardened' nature. Notably, such weapons could also be reserved for use in a conflict where nuclear force would not necessarily be considered an appropriate or a proportional response.

The research on CPGS continued under the Obama administration, which found promise in its development as a way to meet some of its broader goals included in the 2010 Nuclear Posture Review (NPR), which lists reducing the role of nuclear weapons in US national security strategy as one of its five main goals. In this vein, the NPR emphasized the need for conventional capabilities to deter and respond to both potential conventional threats and chemical/biological attacks and for bolstering regional security architectures with non-nuclear means. According to a study produced by the Congressional Research Service, the FY2017 White House budget proposal submitted just before the end of the Obama administration requested $181.3 million to be allocated for Prompt Global Strike Capability Development, which was also the first increase in five years in the total amount requested for the programme. Congress approved this request, although with a few of its own caveats that would allow it some oversight during the continuation of its development.

As of winter 2017 and after nearly a decade of testing and research conducted across the various branches of the US military, the current leading choice for the prompt global strike mission is the Army's advanced hypersonic weapon (AHW), which is set to have flight experiments conducted in 2017 and 2019 and has been allocated $174 billion of the approved $181.3 billion of funds for its research and development.

Global Reactions

While the plans for CPGS have moved forward, they have not done so without being subjected to critique from both domestic and foreign actors alike. As the United States has been seeking to reduce its reliance on nuclear weapons by pursuing this technology, it has paradoxically brought forth concerns on how it could affect strategic stability between nuclear weapons states. While the critiques vary, the most prevalent fears involve concerns around 'nuclear ambiguity', a scenario where a conventionally armed CPGS missile is mistaken as a nuclear missile during launch and accidentally

invites a nuclear response. A related concern that compounds the fear of nuclear ambiguity is that the high-speed travel time of the delivery systems and the incapability of the aged satellite technology and early warning systems to detect such weapons and their only marginally differentiated trajectory patterns will reduce the amount of reaction time available upon launch, therefore putting pressure on world leaders to respond to an incoming missile with little time to collect intelligence. Such pressures might not only bring about a grave mistake but could also result in providing incentives to conduct pre-emptive strike in order to protect one's own high value targets. Finally, there is the additional worry that such high-speed missiles could ultimately be converted, covertly or overtly, for nuclear use therefore resulting in a new strategic offensive weapon that is currently not counted under any sort of binding treaty. In fact the systems have produced enough concern for some arms control advocates to raise the question of whether, even if there is no intention to convert the missiles for use as nuclear delivery vehicles, they should still be subject to strategic arms limitations.

Along with ballistic missile defence, Russia (and to a lesser extent, China) has vehemently opposed the development of CPGS, arguing that the previously mentioned dangers not only jeopardise strategic stability, but could also undermine their deterrent without resorting to using nuclear weapons first. Unsurprisingly, both Russia and China have also begun to develop their CPGS programmes in an effort to tip the scales back. While it is beyond the scope of this article to address whether or not such concerns are justified from a technical perspective, it is necessary to bear in mind that even if a threat is not actually imminent, perceptions can be equally as destabilising.

This leads policymakers and military planners to ask, what are the options that can be pursued in order to assuage such concerns and avoid the scenarios of a conventional, or even nuclear, arms build-up or an invitation of a preventive or pre-emptive nuclear strike? There have been different answers offered by the defence community, including the possibility of developing a new treaty that would place limitations on such capabilities.

However, while the geopolitical climate between the United States and Russia remains strained and CPGS technology remains in the R&D phase, this path would likely lead to a dead end and would essentially put the cart before the horse. Rather it would be more prudent for the US and at least as a start, Russia, to engage in transparency and confidence-building measures that would help dispel both misplaced and justified concerns around the technology, and to begin discussions for follow on measures that could help with future concerns as the technology continues to move closer to acquisition.

Building Confidence and Cooperation with CPGS

The first step that could be taken to kick start such cooperative measures would be to utilise existing cooperative frameworks, such as the New START Treaty Bilateral Consultative Commission (BCC), which is intended to serve as a forum for the treaty parties to raise technical and political matters of concern related to the treaty and its implementation. Considering Russia raised the prospect of CPGS during the original New START negotiations, and the current geopolitical environment is not conducive to the creation of a completely new forum or treaty, utilizing this existing framework to perhaps craft an addendum to the New START Treaty or a memorandum of understanding would not only be appropriate but would provide a way to approach the issue without over expending either side's political capital. Once a forum is agreed upon, each side should seek to address their concerns around one another's CPGS systems paying special attention to: the nuclear ambiguity issue; the scope of use; and nuclear conversion.

To address the problem of nuclear ambiguity and to create more distinction between the firing of a CPGS system missile and a nuclear armed missile, an obvious starting point would be for both sides to establish a formal communications protocol for pre-launch notifications. Additionally, it has been suggested in a study written by former US Deputy Assistant Secretary of Defense for Nuclear and Missile Defense Policy M. Elaine Bunn and Vincent Manzo of CSIS Washington that establishing—or in the case of Russia, re-establishing—a bilateral Joint Data Exchange Centre (JDEC) that would provide early warning information and allow for information to be collected on the trajectory of the missile could aid in

preventing miscalculation. Such data exchanges, along with strategic dialogues that include demonstrations and educational sessions, could improve the information available to foreign counterparts to reduce the possibility for misapprehension while maintaining national security if correctly executed.

Another method that could be utilised to help build confidence is to formally define the scope of use for the system once the acquisition process is initiated, which was originally suggested as another mitigation mechanism in a 2008 study on the CPGS system conducted by the National Research Council. During both the Bush and Obama administrations, the idea that the systems could be used against the nuclear forces of 'rogue states' like North Korea and Iran have cast a shadow of doubt over the stated reassurances that such systems would not also be used on the Russian and Chinese deterrents, despite the fact that there is little to indicate the US is currently seriously considering targeting nuclear forces. Providing a codified 'negative security assurance' of sorts would be one method of reassuring others that previously stated intentions of maintaining these systems for strictly conventional-to-conventional use are in fact true and that any anti-nuclear use would warrant a sanctioned response.

The third main concern, nuclear conversion, will take more effort to address. In the previously mentioned 2008 report released by the National Research Council, an additional cooperative measure proposed as a potential tool to assuage concerns was the installation of continuous monitoring systems. This proposal could be a useful means of increasing confidence by way of a small-scale verification and monitoring regime, should the above mentioned cooperative measures fail to improve Russia's confidence in the survivability of its deterrent with respect to a US CPGS.

Taking a cue from the Bilateral Consultative Commission's parent, the New START Treaty, the Commission could develop a similar, but less intensive, verification and monitoring regime for each side's CPGS programmes once they move past the research and development phase. Such measures could include facilities declarations; a reciprocal inspections system that provides for limited short notice on-site inspections; allowing for the utilisation of National Technical Means, such as satellite/radar/sensor monitoring; and/or a data exchange on an annual or biannual basis of aggregate numbers of arms similar to the exchanges conducted in the New START Treaty. In theory, this transparency should assist in boosting confidence that these conventionally armed warheads are not at risk of being converted for nuclear use and that any such conversion would run the risk of being detected.

Ultimately, the Consultative Commission is not the only possible forum for such discussions, though it offers a logical starting point. It is probable that Russia might not even have an interest in coming to the table at all, and if so, the US might pursue working on a bilateral basis with China, which has been pursuing its own CPGS capabilities. Or perhaps the Commission can still serve as a starting point, with China looped into the talks at a later point in time. Indeed, it would be beneficial to all parties pursuing CPGS if the conversation could be multilateral, whether from the outset or at a later point in time.

Though arms control agreements and the types of transparency and confidence building measures that accompany them are often agreed upon as a reactionary response, the current state of CPGS programmes as merely a hypothetical provides an opportunity for proactive action, drawing on previously agreed frameworks and methods. For the international community, time is currently on our side as these technologies continue to develop and allow for the ability to begin the transparency and confidence building process early in the game, permitting more room for creative problem solving and a more comprehensive solution to the challenge CPGS brings to maintaining strategic stability.

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Verification Watch

UNSC Expands DPRK Sanctions, While Significant Implementation Gaps Remain

By Matt Korda

On 2 June, the United Nations Security Council (UNSC) unanimously voted to expand the sanctions regime against the Democratic People's Republic of Korea (DPRK), the first such expansion since President Trump took office. Resolution 2356 (2017), adopted under Chapter VII of the UN Charter, was enacted in condemnation of 'a series of ballistic missile launches and other activities conducted by the DPRK since 9 September 2016 in violation and flagrant disregard of the Security Council's resolutions.' The resolution added 14 individuals and four entities to the comprehensive list first established by Resolution 1718 (October 2006), which subjected specific individuals and entities involved with proliferation activities to asset freezes and travel bans.

The newly sanctioned individuals include persons connected to foreign espionage and intelligence operations, domestic media outlets, banks, arms deals, nuclear and missile programmes, military procurement and chemical weapons development. The corresponding sanctioned entities include the Kangbong Trading Corporation and the Koryo Bank (financial entities), the Korean Kumsan Trading Corporation (controlled by the General Bureau of Atomic Energy, which is in charge of the DPRK's nuclear programme), and the Strategic Rocket Force of the Korean People's Army (responsible for all DPRK ballistic missile programmes).

In response to the newly-passed resolution, the DPRK issued an unusually lengthy and vitriolic press statement on 16 June, noting that the sanctions 'have grown utterly vicious and barbaric today as to try to obliterate the rights to existence and development of the state and people of the DPRK, destroy modern civilization and bring the world back into medieval darkness.' The statement continues in such a manner, citing numerous cases of perceived hypocrisy and arguing that the United States itself should be subject to sanctions, given that it has 'conducted most of the nuclear tests and ballistic missile launches so far.'

Despite the apparent frustrations of the DPRK, the UN sanctions regime is anything but healthy. The title of Andrea Berger's recent RUSI report is indicative of the widening gap between sanctions policy and practice, characterising the regime as 'A House Without Foundations.' The report notes that despite states being legally bound to incorporate the UNSC resolutions into their national legislations, 'no single measure enjoys robust global buy-in and action,' due to a general lack of interest, capacity, guidance, technical assistance, and priority. The problems in ensuring effective domestic implementation become compounded with the adoption of each new sanctions resolution (see 'Implementing UNSC sanctions on DPRK' in Trust & Verify No. 156).

On the recipient side, the DPRK retains the ability to evade sanctions through the strengthening of its illicit networks abroad, including through the use of foreign flags of convenience registered to tiny island nations like Kiribati and Niue, notes Berger. She has also identified an additional tactic used by the regime—the creation of shell companies with ambiguous names like 'International Global System' registered to individuals falsely self-declared as 'South Korean' or just 'Korean.' Given the inherent difficulties of verifying these claims, the DPRK has enjoyed success in circumventing the UN embargo. Berger additionally notes that other countries are more openly cooperative with the DPRK, including Angola, the Democratic Republic of the Congo, Egypt, Eritrea, Iran, Mozambique, Namibia, Syria, Uganda and Vietnam — all of these states allegedly profit from North Korea's illicit supply chains, with the UN also adding South Sudan, Sri Lanka and Sudan to the list of potential future markets in 2017.

While this latest round of sanctions may add more legal weight to the existing framework, the regime still remains, in Andrea Berger's words, 'a sieve.' The regime would derive greater benefit by patching the holes in its implementation scheme, as each node that is switched off denies the DPRK a method of circumvention or a base for illegal activity. In a June 2017 memo, sanctions veteran Anthony Ruggiero out-

lined a detailed list of actionable recommendations to strengthen the sanctions regime, including sanctioning Chinese enablers of DPRK circumvention, prohibiting DPRK overseas labour and tourist travel, and tackling the issue of Iran-DPRK ballistic missile cooperation. Until such practical steps are taken, the DPRK sanctions regime will retain significant and exploitable gaps.

OPCW elections

By Andreas Persbo

The Director-General of the Organisation for the Prohibition of Chemical Weapons (OPCW) plays a central role in the implementation of the Chemical Weapons Convention (CWC). The present director, Mr Ahmet Üzümcü, began his term on 25 July 2010 (see decision EC-58/DEC.3). He will retire in July 2018, after having completed two terms of service. The process is now underway to find his replacement. But how will the OPCW select its new chief?

The convention itself gives little guidance to member states as to how to select a new leader of their organisation. It makes clear that it is the Conference of the States Parties which, ultimately, appoints the Director-General; see Article VIII.B.21.(d). The appointment is made on the recommendation of the Executive Council; see Article VIII.D.43. The legal procedure closely mirrors that of the election of the Secretary-General of the United Nations, as set out in Article 97 of the UN Charter. The UN Charter does not, however, stipulate the process in which the Secretary-General is elected, and neither does the CWC with respect to the Director-General of the OPCW.

Before Mr Üzümcü was elected, the then-chair of the Executive Council, Mr Jorge Lomónaco Tonda of Mexico, consulted with member states on the preferred election process. His outcome document (EC57/15) was circulated on 16 July 2009. In it, he noted that member states wanted a fair, open, and transparent process where the ultimate decision—if possible—was reached through consensus. Mr Tonda also wrote that he would first consult with member states as to their preferences amongst the candidates. The chair also highlighted that straw polls to identify 'early but clear trends' in 'successive cycles' could assist him in engaging in discussions with the appropriate candidate. This too closely mirrors United Nations practice, where members of the UN Security Council are polled to 'encourage', 'discourage' or express 'no opinion' about a specific candidate.

If needed, the Executive Council should also, as Mr Tonda observed in his 2009 document, hold 'informal' ballots aimed at reducing the number of candidates or—in the last resort—to identify the person that commands the necessary majority. The selection could be finished with a formal vote by the Rules of Procedure of the Council.

The process is very different from that of other international organisations. When the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) elects its Executive-Secretary, the chair, in a similar fashion, begins with informal consultations. After that, however, the organisation's Executive Council moves directly to voting in a series of rounds. After each ballot round, the candidate with the least number of votes is eliminated. If at any time a candidate receives the required two-thirds support of the Council, that person will be appointed. After only two candidates remain, only four additional rounds of voting is allowed, after which the nomination process will restart.

While seeking consensus is important, the chair-driven process has some important drawbacks. Promising applicants may be encouraged to withdraw, forcing the choice to gravitate towards the 'common denominator' candidate. These are likely to be individuals that have not rubbed any particular government up the wrong way. Promising candidates (such as António Guterres), however, have probably had a leadership role in the past, which sometimes forced them to take unpopular decisions. In other words, the chair could be swayed by a country with a particular dislike for a certain individual. If the person withdraws due to pressure from the chair, the organisation may lose out on talent.

The OPCW has been thrust into the public eye because of the war in Syria, which is ironic given that Mr Üzümcü in his election pitch in 2009 said that the organisation 'is not widely known.' It is the recipient of the Nobel Peace Prize, in 2013. There is, therefore, an argument to be made that its chief should be selected in a fully transparent process.

Of course, there is precedent in the recent election of Mr Guterres to the post of Secretary-General of the United Nations. His election was very different from previous ones, which had sometimes been criticised for their opaqueness and secrecy. Indeed, the nominations were made public, and candidates were even participating in televised debates. This allowed them to answer questions about their vision for the United Nations publicly. The candidates for the Director-General of the OPCW have not been announced at the time of Trust & Verify going to press, and are unlikely too. There is no indication that interview sessions with the candidates will be live-streamed on the OPCW website.

Quotes

'his is a momentous occasion not only for the CTBTO, but for the international community. The completion of the hydroacoustic portion of the IMS [International Monitoring System] brings us one step closer to achieving full and increasingly sensitive coverage of the globe, and thus closer to making the planet safer and more secure from nuclear testing.

CTBTO Executive Secretary, Lassina Zerbo, on the certification of the organisation's eleventh and final hydroacoustic station, HA04, in the Crozet Islands (France) in December 2016. CTBTO Press Release 2017/02, 20 June 2017.

We are absolutely against any involvement of the IAEA in verifying nuclear disarmament. Nuclear disarmament is not mentioned either among the IAEA's goals nor functions determined in Articles I and II of its Charter. Therefore, any attempts to involve the IAEA in the talks that contradict its Charter and are aimed at creating some kind of "shadow" verification rules are counterproductive. […] Russia does not accept the initiative that is included into a draft convention on a ban of nuclear weapons, which would put the system of IAEA safeguards, based on its safeguards agreements with individual states, at variance with the goals of these agreements. We note with regret that the initiators of the convention are challenging the fundamental principles of the functioning of the IAEA safeguards system by eroding its goals and tasks. Implementation of the said initiative may open a nuclear Pandora's box and block the IAEA's steady work in all areas, including that of verification.

Speech by Russia's permanent representative to the IAEA Vladimir Voronkov at the IAEA Board of Governors on the point titled "sundry" in response to the invitation of the IAEA to take part in the talks on drafting a convention on the ban of nuclear weapons.'. Eurasia Review, 'Russia 'Absolutely Against Any Involvement Of IAEA In Verifying Nuclear Disarmament' – Speech', 20 June 2017.

The United States has identified potential preparations for another chemical weapons attack by the Assad regime that would likely result in the mass murder of civilians, including innocent children. The activities are similar to preparations the regime made before its April 4, 2017 chemical weapons attack. As we have previously stated, the United States is in Syria to eliminate the Islamic State of Iraq and Syria. If, however, Mr. Assad conducts another mass murder attack using chemical weapons, he and his military will pay a heavy price.

Statement from the Press Secretary, Office of the Press Secretary, The White House (United States), 26 June 2017, warning of unilateral enforcement of compliance with the 1993 Chemical Weapons Convention.

To reinforce norm against chemical weapons use & build support for any response, Trump administration should present its evidence at UN Security Council.

Tweet, Daryl Kimball, @DarylGKimball, Arms Control Association, 27 June 2017, calling for a multilateral approach to such compliance concerns.

Now we are just one people, just one nation. Long live peace.

Juan Manuel Santos, Colombian President, at the completion ceremony for the UN monitored disarmament of FARC weapons; Los Angeles Times, 'Half century of conflict in Colombia comes to close as FARC rebels disarm', 27 June 2017.

S&T Scan

Forensic wood identification: improving compliance through science

By Névine Schepers

With more than 300 million hectares of forest and a considerable domestic lumber industry, promoting and protecting legal timber markets represents an important economic investment for the US. As such, it has long been at the forefront of efforts to combat illegal logging through comprehensive legislative developments, such as the Lacey Act, as well as scientific developments to aid law enforcement in this field. Yet there have often been discrepancies between available legal means and enforcement mechanisms due to the paucity of effective wood identification methodology.

A research group from the US Department of Agriculture Forest Service's (USDA) Pacific Northwest Research Station has been working on a new method of forensic chemical analysis of wood that can identify its geographical origin to an area of less than 100km. Direct Analysis in Real Time (Time-of-Flight) Mass Spectrometry (DART-TOFMS) has been previously applied to successfully identify tree species and genera, and has now been used in this study to determine geographical origin. A full chemical profile of a wood sample is obtained by exposing the sample to helium ions heated to 450 degrees Celsius. The study, performed on samples of Douglas firs from different mountain ranges, compared the trees' molecular differences and was able to pinpoint their geographical origin at a scale under 100km.

Considering that some tree species can only be legally harvested from a certain area, their precise origin is an important factor to take into consideration. The USDA Forest Service research group now seeks to use the molecular analysis of the wood's chemical fingerprints to determine whether the differences between the trees can be linked to genetics, the environment or possibly both. Acquiring a better understanding of wood species' chemical fingerprints can only improve the analysis of data yielded by DART-TOFMS to develop a detailed database that could be used by law enforcement agencies in the future.

Other methods for identifying timber exist and vary greatly from ones based on non-inherent features of wood, such as paper-based identification or physical barcoding systems (see 'Tree barcoding begins in Liberia to tackle illegal logging' in Trust & Verify No. 134), to ones based on inherent features of wood such as the DART-TOFMS method. Given the fact that documents can be forged and tags can be removed, only forensic identification, which is based on inherent features, is considered to be sufficiently reliable and accurate to be presented as evidence in a court of law. However, there is no single forensic identification method that can provide precise indications for all key characteristics (species, genera, geographical origin, age). With further research, DART-TOFMS could change that.

Compared to other forensic identification methods such as DNA barcoding, DNA fingerprinting or radiocarbon analysis, DART-TOFMS also produces fast results, requires little or no sample preparation and, apart from the price of the initial equipment, is a relatively cost-effective screening solution. Dormontt et al. (2015) give a detailed assessment of most existing methods in 'Forensic timber identification: It's time to integrate disciplines to combat illegal logging' and note that these tools need to be adapted for every new species that is added to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Although the Douglas fir was used for the purposes of this study, applying the DART-TOFMS method to species which feature in CITES would certainly improve certification and legality verification measures.

Efforts to tackle illegal logging at the national and international levels have been slowed in recent years for a variety of reasons, including the appearance of new markets with less stringent policies than the US or the EU and, from a technical point of view, lack of funding for wood identification research projects. Legal compliance is also more difficult in some countries such as Brazil due to complex bureaucratic procedures. Developing fast and precise identification techniques such as DART-TOFMS not only benefits national

administrations that already have the necessary legal infrastructure but lack the technological tools to support it, but also those that don't yet have sufficiently stringent legal means to construct a solid verification framework.

New developments in warhead verification methods

By Névine Schepers

Warhead authentication is a notoriously difficult challenge within the field of nuclear disarmament verification due to the requirement to balance an effective verification process with the need to preserve confidential information related to the design of the inspected warheads. Both parties in the process, the host and the monitor, have a vested interest in ensuring sufficiently secure interactions in order to build up mutual confidence. Substantial research has been carried out to develop new verification methods that can reliably authenticate nuclear warheads without revealing confidential data in order to facilitate the effective implementation of future arms control agreements that are likely to limit the total number of nuclear warheads within a country's nuclear arsenal, including non-deployed warheads as well as those awaiting dismantlement.

Warhead authentication methods are divided between a template-based approach and an attribute-based approach. The former is based on comparing the signature of a warhead, which is made up of a set of characteristics, with a reference item often called the "golden warhead", whereas the latter verifies whether a warhead is indeed a warhead by confirming a range of key attributes. Determining the "golden warhead" or the key attributes and their values presents a challenge and requires an agreement between the host and the monitor.

Information barriers are used in both approaches to protect sensitive data. Within the context of the UK-Norway Initiative, VERTIC collaborated with institutes from both countries on information barrier technology (see VERTIC, Matters No 9, 2010). A prototype system, made up of a radiation detector and an electronic unit with an integrated information barrier, was designed as result of this joint research endeavour that sought to promote cooperation between a nuclear weapon state and a non-nuclear weapon state on warhead verification research.

Zero-knowledge proof (ZKP) methods have subsequently been developed as an alternative to information barrier systems to avoid the hurdle of still having to acquire and analyse sensitive data even if it cannot technically be accessed. ZKP methods use mathematical cryptography to ensure no sensitive information is stored or revealed, and can determine whether two objects are alike without disclosing them. Princeton University has been working on a template-based approach system that uses a ZKP method. Their system relies on the host party to conduct all measurements, causing a certain trust imbalance between the host and the monitor.

Sandia National Laboratories has strived to rectify this particular imbalance through the development of a new warhead verification method called CONFIDANTE, which stands for 'Confirmation using a fast-neutron imaging detector with anti-image null-positive time encoding'. CONFIDANTE is a ZKP confirmation method that also takes advantage of previous research done by Sandia on time-encoded imaging. This approach only requires a single detector placed within a cylindrical coded mask which rotates to carry out measurements. Verification is achieved by checking that the detector measures an unchanging rate consistent with statistical noise, which is the only information that is stored on the detector. As a result, the monitor could be carrying out the measurements instead of the host, levelling the trust balance between both parties. CONFIDANTE has successfully conducted a first proof-of-concept measurement and will be subjected to further feasibility tests.

CONFIDANTE could have important implications for future treaty verification procedures. Although the issue of agreeing on a "golden warhead" remains, the system developed ensures that no sensitive data is actually stored in the device, therefore enabling the monitor to carry out the verification procedure and the host to be certain that no sensitive information can be accessed, revealed or even reverse-engineered as the detector stores nothing but statistical noise. There would be no fear of accidentally transferring proliferative information, and ensuring effective verification would not be at the expense of excessive transparency. Technical developments such as CONFIDANTE are paving the road for in-

creased confidence measures and further nuclear arms control efforts.

Monitoring mechanisms at gas centrifuge enrichment plants

By Névine Schepers

Gas centrifuge enrichment plants (GCEPs) are a key component for the production of enriched uranium thus making them subject to the International Atomic Energy Agency's (IAEA) Comprehensive Safeguards Agreements in the case of non-nuclear weapon states and Voluntary Offer Agreements for nuclear weapon states. Compared to other methods used to enrich uranium such as gaseous diffusion, the use of gas centrifuges is more energy-efficient, cost-effective and safer. They are therefore likely to feature more prominently in the future, meaning that sound verification procedures are required to ensure that possible misuse is detected in a timely manner.

In a recently published paper titled 'Timely verification at large-scale gas centrifuge enrichment plants', Walker and Goldston explore different misuse and diversion scenarios at GCEPs involving the production of more than the declared amount of enriched uranium. They also take a detailed look at existing verification technologies that could be applied to avoid these scenarios. Within the context of the Comprehensive Safeguards Agreement, the IAEA already has a variety of tools at its disposal which were developed as part of the Hexapartite Safeguards Project, ranging from periodic interim inventory verification to limited frequency unannounced access (LFUA) inspections in cascade halls. The latter is quite an important tool since it gives inspectors access to facilities that would otherwise be off limits during other inspections. New technological developments that have important implications for the future of IAEA safeguards are underway such as On-Line Enrichment Monitors (OLEMs), Load Cell Monitors (LCMs) and Unattended Cylinder Verification Stations (UCVS). According to the authors, a combination of these three systems would greatly improve the IAEA's current safeguards framework by providing better accuracy and more effective control systems while also reducing the need for on-site visits.

Out of the three methods, OLEMs are already in use and have started to complement traditional sampling and analysis methods by measuring 'the density of uranium 235 in the gas flowing through the unit header'. URENCO enrichment plants have deployed OLEM systems and one is notably being used to verify Iran's uranium enrichment activities under the Joint Comprehensive Plan of Action (JCPOA) at Natanz (see 'Monitoring Iran's uranium enrichment in real-time' in Trust & Verify No. 152).

Whereas OLEM systems are non-intrusive, LCM systems require the handling of data that is considered sensitive by operators. An LCM system can be used to detect excess production by monitoring the transfer of material from cascades to cylinders. From a safeguards perspective, LCM systems could be used to confirm the number of cylinders processed between on-site inspections and any changes in weight of declared cylinders between feed and withdrawal stations. Research into LCMs is in progress to solve the issue of having to protect commercially sensitive information.

UCVS is another technology currently being developed by the Pacific Northwest National Laboratory and Los Alamos National Laboratory that has a lot of potential for improving verification mechanisms (see 'Automation in nuclear inspections' Trust & Verify No. 155). A UCVS would make use of various measurement methods to remotely determine the uranium mass in feed, product and tail cylinders. These measurements would provide further consistency controls than the ones provided by OLEMs for instance.

In its 2016 Safeguards Statement, the IAEA declared it had found no indication of diversion of declared nuclear material. It is however still evaluating cases of absent undeclared nuclear material in 55 states. Hastening this process in the future will rely on the development of technologies such as those mentioned previously. Further deployment of OLEM systems and completing research on UCVS are key priorities for the IAEA's project on unattended measurement techniques in 2017. In the case of large-scale GCEPs, implementing more effective safeguards in combination with LFUAs would substantially reduce the risk of misuse and/or diversion of enriched uranium. Remotely operated in real time monitors, together with cameras or motion detectors, could rely on the

possibility of LFUAs to follow-up on inconsistencies. They would take a considerable burden off inspectors' shoulders by performing most of the routine measurements remotely. Although the costs of developing and implementing technologies such as OLEMs, LCMs and UCVS are not unsubstantial, they are cost-effective in the long-term given how much the IAEA currently spends on on-site inspections.

Centre News

Director's reflections

Andreas Persbo, Executive Director

The second quarter of 2017 was eventful for subscribers to Trust & Verify interested in nuclear affairs. In May, state parties to the 1968 Nuclear Nonproliferation Treaty gathered in Vienna to participate in the first preparatory meeting for the next review conference, scheduled to be held in 2020. Later, in June, states met in New York to negotiate a treaty on the prohibition of nuclear weapons.

The NPT preparatory committee, chaired by Ambassador van der Kwast of the Netherlands, faced some thorny issues. The 2015 Review Conference had failed to adopt a final document over divisions relating to a Weapons of Mass Destruction Free Zone in the Middle East. The chairman also faced growing discord over the International Atomic Energy Agency's (IAEA) safeguards system, and concern over the future of nuclear arms reductions. Despite this, the meeting was very quiet. The discussion on the Middle East was muted, and the debate on nuclear safeguards and disarmament verification marked by cautiousness.

The chairman's 'factual summary' welcomed, with respect to disarmament, 'cooperative efforts … towards the development of nuclear disarmament verification capabilities' especially in regards to 'capacity-building, testing verification technologies and elaborating model verification protocols' (see document NPT/CONF.2020/PC.I/WP.40, 25 May 2017). It noted the role of the IAEA in the area of verification. In regards to the development of safeguards, participants welcomed the 'open dialogue' between them and the IAEA on safeguards matters. They noted the Agency's work on 'updating, developing and implementing State-level safeguards approaches.' The summary fell short of endorsing the so-called Additional Protocol as the new verification standard, despite the calls of several states. The entire meeting was characterised by a 'wait and see' attitude, and this may well increase the workload for the chair of next year's preparatory meeting, Ambassador Adam Bugajski of Poland.

In parallel, some may have expected a smooth running of the conference to negotiate a ban on nuclear weapons. However, a draft text released by the chair, Costa Rican Ambassador Elayne Whyte Gómez left many participating governments wanting (see document A/CONF.229/2017/CRP.1, 22 May .

National Implementation Measures

Scott Spence, Programme Director

During this quarter, National Implementation Measures (NIM) programme staff worked on legislation surveys for the implementation of the Biological Weapons Convention (BWC) for three states. They also completed drafts of new legislative analytical tools for the International Health Regulations (2005) and Codex Alimentarius, as part of their work under EU CBRN Risk Mitigation Centres of Excellence Initiative Project 53.

On 25 April, Senior Legal Officer Sonia Drobysz was invited to a doctoral seminar at Sciences Po Paris, France to discuss the work of Dr Mary Mitchell on the United States' strategic trusteeship and nuclear testing in the Marshall Islands. On 5 May, she attended a one-day conference on French nuclear history, also at Sciences Po Paris.

From 22 to 24 May, NIM Programme Director Scott Spence attended the 1st International Scientific Conference on CBRNe in Rome, Italy. Mr Spence spoke during the parallel session on "CBRNe Policies, International Legal and Economic Framework", where he presented VERTIC's approach to CBRN legal analysis and outreach.

In June, Dr Drobysz travelled to Panama City, Panama, to participate in a workshop on Legislation and Biological Threat Reduction for Member Countries of the Regional International Organization for Plant Protection and Animal Health (OIRSA). Organised by the World Organisation for Animal Health (OIE) from 20 to 22 June, the workshop focussed on the critical role of Veterinary Services in biological threat reduction. Ms Drobysz gave a presentation on the legislative framework for biological threat reduction and facilitated sessions during a table top exercise.

Verification and Monitoring

Larry MacFaul, Programme Director

In May, the programme focused on activities under its project exploring the potential role of a Group of Scientific Experts (GSE) on nuclear disarmament verification, supported by the Norwegian Ministry of Foreign Affairs. First, we released a new VERTIC Brief on 'Defining a Group of Scientific Experts for Disarmament Verification', Brief No. 27, authored by programme staff. This paper provides an outline of the factors surrounding the potential establishment of such a group and reported on two workshops run in April to gather regional views on the issue from Africa and Europe.

The VM team, including Larry MacFaul, Programme Director; Andreas Persbo, Executive Director; Noel Stott, Senior Researcher; and Katherine Tajer, Researcher, attended the Nuclear Nonproliferation Treaty Preparatory Committee meeting in Vienna, from 9-12 May. There, we hosted a side-event discussing the viability of a GSE during which Noel Stott presented on VERTIC Brief No. 27 and explained the aims of the project and the progress thus far. We also hosted an informal consultation with European states at the Vienna Center for Disarmament and Non-Proliferation (VCDNP), on the same issue. We would like to extend our thanks for a very successful event to both the VCDNP and the attendees who fostered an interesting, free-flowing and productive discussion. The team also enjoyed attending a cross-section of events and meeting with colleagues in the field.

Later in the month, Noel Stott participated in the 39th ESARDA Symposium on Safeguards and Nuclear Non-Proliferation in Germany from 16-18 May 2017. He delivered a presentation on the disarmament verification project focusing on the means of a GSE to increase the common knowledge-base on options for nuclear disarmament verification. Throughout the rest of May and June, we continued work revising project materials and planning next steps.

During this period, we held planning meetings with the NIM Programme and partners CRDF Global for a new joint project focusing on regulatory and licensing support for Oman, funded by the US Government's Export Control and Related Border Security (EXBS) Program. We also continued

scoping meetings with our partners on remote sensing equipment used under the Open Skies Treaty, supported by the US Department of State, and investigated further opportunities to promote nuclear security reporting under our project funded by the Nuclear Threat Initiative and the Netherlands Ministry of Foreign Affairs.

During 29 May-31 May, Angela Woodward participated in an Asia-Pacific Leadership Network for Nuclear Non-Proliferation and Disarmament (APLN) plenary meeting, as a member representing New Zealand, convened in Jeju, South Korea. VERTIC Trustee, Lord Browne, Chair of the European Leadership Network, also participated in this meeting. Angela Woodward then participated in the 2017 Jeju Forum for Peace and Prosperity, moderating a panel discussion on cybersecurity on 30 May.

In early June, Andreas Persbo travelled to Washington DC to attend a seminar run by the James Martin Center for Nonproliferation Studies (CNS) on the nuclear ban treaty. While there, he also met with partners related to our other projects.

Later in June, we were also delighted to release another VERTIC Brief on 'Port State Measures Agreement: Tackling IUU fishing through inspections', Brief No. 28. This brief, authored by Simeon Dukic and Matteo Zerini, examines the features of the inspection mechanism set out under the agreement concerning illegal, unreported and unregulated fishing, which has recently entered into force.

Ana Grusa Golja and Madison Estes completed their internships at VERTIC, and we would like to thank them greatly for their contributions and assistance and wish them well in the future. We recently welcomed Matt Korda and Névine Schepers as new interns for the programme. Matt is completing an MA in International Peace & Security in the Department of War Studies, King's College London. Névine holds a dual Masters degree in European and Asian Affairs from the universities of Sciences Po, in Paris, and Fudan, in Shanghai, and a BA in Asian studies from the University of Sydney. She previously worked as an analyst at IB Consultancy in the Netherlands. We are excited to have them both working with us.

Finally, we were very sad to say farewell to Katherine Tajer, Researcher, who has left VERTIC to take up a post with the US National Nuclear Security Administration (NNSA). Katherine has worked for VERTIC for four years, first as an intern, then consultant, administrator and finally as Researcher in the VM Programme. Throughout Katherine's time at VERTIC she has been an invaluable and highly dedicated member of the team, always willing to tackle new tasks and areas and contribute to the effective running of the organisation. Katherine will be greatly missed but we are delighted that she has moved to a great position at the NNSA with whom we enjoy working – so we will undoubtedly be crossing paths in the near future.

Grants and administration

Mariama Gerard

In June 2017, VERTIC welcomed Matt Korda and Névine Schepers to the Summer Internship Programme. Both interns are working in the Verification and Monitoring programme under the supervision of Andreas Persbo and Noel Stott. Matt is an MA International Peace & Security candidate in the Department of War Studies, King's College London. Névine holds a Dual Masters' Degree in European and Asian Affairs from the universities of Sciences Po in Paris and Fudan in Shanghai, and a BA in Asian studies from the University of Sydney.

The Verification and Monitoring programme's funding bid for a non-proliferation project to the UK Foreign Office's Counter Proliferation Programme was successful. VERTIC also secured a funding contract with CRDF Global to work on regulatory and licensing support for a country in the Middle East. This project, which will be carried out by both the Verification and Monitoring and National Implementation Measures programmes, commenced in May 2017. Mariama Gerard, VERTIC's Administrator, continued to participate in discussions with VERTIC's landlord, The Ethical Property Company, about the sale of our current premises, Development House, in Shoreditch. VERTIC will move to EPC's new office building, The Green House, in the Bethnal Green area of London in May 2018.

Mia Campbell was appointed a VERTIC Trustee at the ordinary board meeting on 26 May 2017. She was also appointed Chairman of the Finance Committee. Ms Campbell is a Manager at the UK anti-fraud charity the Fraud Advisory Panel. The organisation is delighted to have her support and looks forward to working with her.

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building trust through verification

VERTIC is an independent, not-for-profit, nongovernmental organisation. Our mission is to support the development, implementation and effectiveness of international agreements and related regional and national initiatives, with particular attention to issues of monitoring, review, legislation and verification. We conduct research, analysis and provide expert advice and information to governments and other stakeholders. We also provide support for capacity building, training, legislative assistance and cooperation.

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EDITION 157
Editing by Angela Woodward; Production by Andreas Persbo.

ORIGINAL DESIGN
Richard Jones

SUBSCRIPTION
Trust & Verify is a free publication. To subscribe, please enter your e-mail address in the subscription request box on the VERTIC website. Subscriptions can also be requested by contacting Mariama Gerard at mariama.gerard@vertic.org.

PUBLICATION DISCLOSURE STATEMENT
This paper is principally produced through research support from the Joseph Rowntree Charitable Trust (JRCT). The terms of this arrangement have been reviewed by VERTIC. and is considered compliant with the charity's objects as defined in Article 4 of the Articles of Association (2011).