Trust & Verify

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Disarmament: security context and verification challenges

It is now, perhaps more than ever, important to link nuclear disarmament to its multilateral context. Throughout four decades of Cold War, the US and the Soviet Union have engaged in successive agreements, and occasionally less formal undertakings, to reduce their nuclear arsenals. Such measures ranged from reducing numbers of nuclear weapon delivery vehicles and launchers to creating better communication channels and hotlines. These measures were primarily aimed at enhancing strategic stability by minimizing the likelihood of a nuclear exchange and preemptive strikes. They were also designed to reduce the likelihood of any such exchange escalating further. Their impact on enhancing the global non-proliferation regime was a secondary, but welcomed, by-product.

The present discourse surrounding disarmament carries a different flavour. Current disarmament initiatives seem to respond to a different set of challenges than those during the Cold War. The prospect of a superpower nuclear exchange has been dwarfed by the many challenges facing the non-proliferation regime and the dangers of non-state actor access to radiological and nuclear capabilities. Consequently, the current initiatives for disarmament are more likely to be multilateral in scope and linked more strongly to the broader non-proliferation regime.

The change in the international security agenda was best captured by four Cold War statesmen in their open call for global nuclear disarmament. In January 2007, George Shultz, William Perry, Henry Kissinger and Sam Num, widely considered to be prudent and hard-headed on security issues, called for rethinking the main tenets governing US nuclear policy. An underlying theme running through their widely cited Wall Street Journal editorial was that the vision to achieve nuclear disarmament, coupled with practical measures, would prove essential for the future health of the non-proliferation regime and to seal off non-state actor access to radiological and nuclear capabilities.

Since 2007, public support for disarmament by officials from nuclear weapon states has increased steadily. In particular, later that year, UK Foreign Secretary Margaret Beckett announced that the UK would take practical steps towards becoming a 'nuclear disarmament laboratory'. With the election of US President Obama, the call for disarmament has slipped back into the lexicon of official security discourse. In his April 2009 Prague speech, President Obama laid out his administration's nuclear agenda; the vision for a nuclear free world was at its heart. At

In this issue ...

Hassan ElBahtimy discusses verified nuclear disarmament, Richard Guthrie writes about the 2009 BWC Meeting of Experts and Andreas Persbo writes about requirements for a verified ban on fissile material production for weapons purposes.

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the same time, President Obama outlined plans for strengthening the non-proliferation regime and called nuclear terrorism 'the most immediate and extreme threat to global security'.

Current disarmament discourse is likely to present future disarmament efforts with a new set of challenges. A credible vision for a nuclear free world will have to involve deep cuts through warhead dismantlement rather than the standard Cold War practice of reducing delivery vehicles. Nuclear weapon states may have to re-consider the path aborted prematurely during START III negotiations in the mid-nineties. Verified warhead dismantlement is not only an essential component of the vision of a nuclear weapon free world, but can also increase confidence that this disarmament is irreversible.

Furthermore, future disarmament steps will have to accommodate increased transparency and enhanced verifiability to satisfy a wider audience of nuclear as well as non-nuclear weapon states. The remainder of this article explores the technical challenges facing a verification regime for nuclear warhead dismantlement.

What is warhead dismantlement?

Nuclear warheads have to go through a dismantlement process where the warhead is reduced to its various components. Warhead dismantlement follows similar steps as those needed for warhead assembly, but in the reverse order. Through successive stages, the warhead is reduced to its fissile core and various waste streams of disassembled components including high explosives, wirings, and triggers among others. These streams vary considerably in the level of security classification applied to them and how they are ultimately disposed of.

Although each type of warhead is unique and requires different tools and procedures for dismantlement, some steps remain the same for all warheads. For a simple fission plutonium warhead, two such steps stand out. One is the mechanical removal of the physics package from the warhead, which contains the fissile core and high explosives, leaving behind an empty shell. The other is the further disassembly of the physics package where high explosives are separated from the fissile pit. There is, however, a risk of the separation triggering an explosion. That risk is reduced if the physics package includes 'insensitive high explosives'. Disassembly cells usually have robust containment features to address any such accidental explosions.

Once the fissile core has been separated from the high explosives, it can be dealt with in a number of ways. Further processing can convert it for use in a civilian fuel cycle. Plutonium can be converted to an oxide suitable for the fabrication of mixed oxide fuel. Alternatively, plutonium can be mixed with additional radionuclides to alter its classified properties and to inhibit recovery or reuse. It can later be put into long term storage in accordance with international standards for nuclear waste management.

Warhead dismantlement primarily takes place in a disassembly facility. Assembly facilities can double up as disassembly facilities. Other facilities are also involved in the dismantlement process, particularly at the back and front ends. Warheads destined for dismantlement start off in military custody either in storage or in deployment sites. At the back end, further processing of the disassembled fissile core and its final long term disposal can increase the list of facilities involved.

Although warhead disassembly is a complicated and potentially hazardous undertaking, this process is part of the natural life cycle of a nuclear weapon. Nuclear weapons have an expiry date. Indeed, warhead disassembly is an essential operation both in the maintenance of an active nuclear stockpile and in the retirement of obsolete nuclear weapons systems. Some components are particularly valuable (for instance the fissile core) and warheads can be designed to allow for the re-use of such components.

Verifying warhead dismantlement

The challenge in verifying dismantlement is to carry out a highly classified operation whilst allowing sufficient information to be gathered by an inspection team. The classified nature of the facilities involved and some parts of the disassembly operation coupled with multiple health and safety considerations add significantly to the complexity of the verification regime.

The verification regime for warhead dismantlement cannot escape addressing two main questions. First, whether the item presented at the beginning of the process is indeed a nuclear weapon, rather than a fake or dummy, and matches the class and type declared. Second, at the end of the process, that the warhead in question has successfully undergone dismantlement and has been reduced to its basic constituent components. To address those challenges, verification literature suggests some solutions, explored below.

Authentication of warheads

There are inherent difficulties for a verification regime in determining whether a presented item is a nuclear weapon or not. For security and non-proliferation reasons, inspectors would not have direct access, either visually or through monitoring equipment, to a nuclear warhead. Moreover, various diagnostic methods routinely used for safety checks and staging of warheads throughout their life cycles, provide measurements that are, for the same reasons, off limits to the verification regime. In order to overcome these difficulties, verification literature has explored conducting measurements on warheads through 'information barriers'.

Information barriers are selective filters that provide a truncated reading of a wider measurement in order to withhold classified design details. Instead of showing the full spectrum of a sensitive measurement, the information barrier provides a simple binary pass or fail reading, which states whether the item in question fulfils agreed criteria.

Although the concept behind the information barrier is straightforward, designing one is far from easy. Parties to the verification regime will have to navigate through national security classifications and international non-proliferation regulations to agree on which criteria are specific to the warhead to be dismantled. Furthermore, any information barrier used has to gain all parties' confidence that it functions exactly as authorized, and shows the necessary data, but no more and no less than agreed. Consequently the information barrier itself would need to be adequately checked and authenticated.

Previous attempts to design information barriers were pursued as part of the 'trilateral initiative' between the US, Russia and the International Atomic Energy Agency (IAEA). Currently, the UK-Norway Initiative on verifying nuclear dismantlement is developing its own information barrier. The information barrier designed under the UK-Norway initiative intends to address the additional challenge of developing a device that could gain the trust and confidence of both a nuclear weapon state and a non-nuclear weapon state.

Maintaining chain of custody

Once confidence is established that the item presented at the beginning of dismantlement process is a nuclear warhead, the verification regime would need to ensure that this specific warhead was the one dismantled. This can be done by setting up a chain of custody. The chain of custody aims to track the movement of the warhead and its components from the point where authentication is established until final disposal or storage.

Through applying various 'tamper indicating devices' (such as tags and seals), as well as various monitoring methods, a chain of custody creates a controlled environment for the warhead and its components as they proceed through the different stages of dismantlement. This surrogate environment is porous enough to allow controlled entry and exit of items necessary for dismantlement, along with waste streams of dismantled components.

When warheads (along with their most sensitive components) are moved from one area to another during the dismantlement process, they are always enclosed in containers. These containers can be tagged, sealed and regularly checked and verified before allowing access to the enclosed components or whenever a sealed container leaves a monitored area. Chain of custody should be maintained throughout the dismantlement process. This includes phases when the warhead or any of its components are transported between facilities or are put into temporary storage, pending scheduled dismantlement. The following section examines the challenges in maintaining chain of custody throughout warhead dismantlement.

When to start chain of custody?

A key challenge is to identify at what point to start the chain of custody. As a rule, chain of custody should proceed from the point where a warhead is authenticated and continue uninterrupted thereafter. In addition, the earlier the warhead is authenticated and chain of custody established, the higher the confidence generated from verification. Moreover, early access to a warhead while in military custody can facilitate the authentication process. Access to a warhead in deployment or storage sites can help to determine the type of warhead to be dismantled and whether it belongs to a tactical or strategic inventory.

However, that is not without challenges. Nuclear warheads are invariably kept in the custody of national defence establishments either mated to delivery platforms or in storage. Consequently, authentication and chain of custody procedures at this stage could expose deployment and storage sites. Whether nuclear weapons states would be willing to provide access at this stage is an open question. The cost and benefits of an early start needs to be thoroughly examined before the issue can be satisfactorily settled.

Verifying black boxes

During dismantlement there are certain operations that nuclear weapons states do not want inspectors to see. Due to their sensitive nature, verifying such operations warrants extra measures to maintain the chain of custody. These extra challenges have led to this kind of verification being called 'black box verification'. Two operations in particular are highly sensitive: the mechanical separation of the physics package from the warhead and the separation of high explosives from the fissile pit.

Inspectors would be prohibited from seeing or monitoring the mechanical separation of the physics package because that might expose its configuration as well as its sensitive electronic components (such as triggers and wirings). Further disassembly of the physics package into high explosives and the fissile pit can also expose sensitive information about how these two parts interact.

Verification of these 'black box' operations therefore requires a more hands-off approach that nevertheless maintains an adequate level of assurance. In order to maintain a satisfactory chain of custody on these highly sensitive operations, while lacking direct access to the warhead components, one can establish a 'portal perimeter control' on the facilities. Portal perimeter control ensures that inspectors can check all items passing into and out of the areas where these operations are taking place. For the effective application of 'portal perimeter control', access to such areas should be limited to a minimum number of entry and exit points. This would allow inspectors to effectively control access to areas where they are not allowed to follow sensitive operations. Areas within the controlled perimeter will have to be swept, using detectors, directly prior to establishing the perimeter. This will help ensure the absence of any radioactive components in those areas before dismantlement commences.

Out of the two 'black box' operations, the establishment of a perimeter around the disassembly cells—where the high explosives and fissile pit are separated—is the more challenging. Disassembly cells are radiologically contaminated areas and thus subject to extra health and safety measures. As noted above, the design of disassembly cells allows for containment of any accidental explosion during separation of physics package components. A verification regime will have to accommodate these special containment features. The host country may be even more cautious about access to disassembly cells if they are also used in warhead assembly or stockpile maintenance operations. Consequently such states might prefer either weaker or more 'distant' portal perimeter control measures.

Which waste streams to follow?

As previously mentioned, warhead dismantlement results in a range of non-nuclear end-streams with various levels of classification. While some of these waste streams can be commercially disposed of relatively easily, nuclear weapon states will apply further processing to others, to hide their classified properties. Designing a cost-effective verification regime requires identifying which waste streams need to be followed until final disposal. While a regime that maintains a meticulous chain of custody throughout the process could provide higher levels of confidence, such a regime could possibly be costly. The benefits of higher confidence would need to be weighed against the higher costs.

An alternative approach is to decide selectively on which waste streams are worthwhile verifying until the end. Certain warheads produce waste streams that are characteristic to their class. Consequently, following these streams would increase confidence about the warhead class, and thus aid authentication. Similarly, if by verifying the disposal of certain components, the ability to regenerate a warhead is further diminished, efforts to verify that stream could also be worthwhile.

Transportation

Dismantlement involves moving nuclear warheads and their components within and between facilities. Maintaining chain of custody requires applying appropriate measures to both on-site and off-site transportation. The verification regime would need to be able to cope with classified transportation timings and routes.

Moreover, special vehicles are used to transport warheads. The design and configuration of the storage area that houses the warhead during transportation is classified. This can limit inspectors' ability to apply containment measures on the vehicle, such as tags and seals.

Verifying conversion of fissile core

Further processing of the fissile pit aims at converting its fissile component and changing its isotopic make-up to an unclassified state which could be used in a civilian fuel cycle, or to put it into long term storage. Further reprocessing of the fissile core is likely to take place in a fissile material complex, outside the disassembly facility.

The methodology for material accountancy is highly developed and has been used by the IAEA in its safeguards operations. However, applying material accountancy where the feed stream is composed of fissile material in classified weight and isotopic composition can prove to be a challenge. Also, nuclear weapon states will not want any measurements taken on the converted non-classified isotopic form to allow deduction of properties of the classified fissile precursor. A possible alternative to material accountancy at this stage is to resort to measures similar to those used in verifying black box processes. In this case, a chain of custody can be maintained through establishing portal perimeter monitoring around the conversion facilities.

Final disposal

Final disposal after conversion involves either storage or re-use of the fissile material in a civilian fuel cycle. In cases where the fissile components of the warhead are put into long term storage, a range of procedures can be applied to verify its final disposal. Remote monitoring and surveillance techniques coupled with tamper-indicating devices can be used to verify that the fissile material is stored securely with no unauthorized access. In cases where the fissile component is further processed and converted to feed into the civilian fuel cycle, IAEA safeguards can be applied to ensure that this material is not diverted back to the military fuel cycle.

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Biological Weapons Convention considers disease surveillance

For a week in August 2009, states parties to the 1972 Biological and Toxin Weapons Convention (BWC) discussed disease surveillance and containment. It may seem paradoxical at first glance that these issues should be considered in such detail at a meeting of an international treaty that is primarily concerned with arms control and international security. This paradox can be explained if one understands that the use of biological weapons—whether in warfare or as a terrorist or criminal act—is nothing more than the deliberate use of disease. Indeed, it is apparent from this perspective that there is much common ground in detection and responses to outbreaks of disease, whether they stem from natural, accidental or deliberate causes.

Moreover, there are relevant issues to questions of arms control implementation and verification. Efforts to detect deliberate disease can only be effective if there is greater knowledge and understanding of what the natural patterns of disease are. A parallel can be drawn here with the need to enhance knowledge of geology and seismic methodology in order to verify the 1996 Comprehensive Test Ban Treaty. To have confidence in distinguishing and identifying anything suspicious, and not simply anomalous, detailed knowledge is needed of normal conditions.

Much was made of the new World Health Organization's International Health Regulations which require countries to report outbreaks of disease that could constitute an international public health threat, but little was said at the meeting about what is sometimes known as the 'second diagnosis' problem. The first diagnosis is establishing that there has been an outbreak of a particular disease. The second diagnosis is establishing what caused the outbreak to take place—was it natural, accidental or deliberate?

The international focus on the global impact of the Novel Influenza A (H1N1) strain (commonly referred to as 'swine flu') has illustrated how natural outbreaks have an impact on matters beyond individuals' health, such as implications for economic security and even national security. Ironically, a number of delegations had a reduced attendance of experts in Geneva as they had important roles to fulfil at home owing to the H1N1 pandemic.

The Meeting of Experts

The states parties met in Geneva as the 'Meeting of Experts' (MX) during 24-28 August 2009. The topic under discussion was: 'With a view to enhancing international cooperation, assistance and exchange in biological sciences and technology for peaceful purposes, promoting capacity building in the fields of disease surveillance, detection, diagnosis, and containment of infectious diseases: (1) for States Parties in need of assistance, identifying requirements and requests for capacity enhancement; and (2) from States Parties in a position to do so, and international organizations, opportunities for providing assistance related to these fields'. This topic was agreed at the sixth review conference for the BWC which was held at the end of 2006 and forms part of a new 'inter-sessional process' for the period 2007-10 which includes a meeting of experts in the middle of each year and a meeting of states parties at the end of each year.

The MX provided a chance for the exchange of experiences and ideas through working papers, plenary statements and more focused working sessions. There was also a poster session and ten side events. The MX adopted a procedural report to which is appended a compilation of 'Considerations, Lessons, Perspectives, Recommendations, Conclusions and Proposals Drawn From the Presentations, Statements, Working Papers and Interventions on the Topics Under Discussion at the Meeting'. The compilation intends to summarize the ideas raised at the meeting in order to help officials from states parties consider which might be relevant in their own circumstances. Documents from the meeting are available on the BWC Implementation Support Unit (ISU) website (www.unog.ch). The ISU has placed recordings of parts of the meeting on a free web video streaming site (www.ustream.tv).

From the local to the global

A key understanding reached by many participants was on the need to integrate the activities that already occur at four different levels—local, national, regional and global. However, it is not possible to specify from a global perspective precisely which measures should be implemented at more local levels. This also applies for lessons learned—measures that might improve surveillance in one jurisdiction or location may not be relevant or suitable in another. Different geographical areas are affected by very different patterns of infectious disease and this factor, combined with political and economic influences, results in considerable variation in systems. In addition, a surveillance system can be undermined if there is no system (or an incompatible system) in a neighbouring jurisdiction. However, initiatives exist to tackle this problem. For example, in Latin America, disease surveillance arrangements are being made through UNASUR—the Union of South American Nations—to avoid such a situation. This has also led to common use of terminology and disease classifications in the region.

The capabilities for disease surveillance vary considerably around the world. Capacity building was therefore an important issue under consideration. Some assistance recipients are also donors. For example, India both receives and provides capacity building assistance and now has a pan-African assistance project of its own. The human factor was considered particularly important. Equipment is useless without adequate training for personnel and turnover of staff means training has to be on-going. This is a key factor in making assistance efforts sustainable. For effective capacity building, training has to go far beyond the technical aspects of donated equipment.

The capacity-building issues relating to disease surveillance have parallels with questions of implementing the more traditional aspects of arms control policy—an area VERTIC has been active in with its National Implementation Measures project.

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Richard Guthrie prepared the 'Daily Report' series on the Meeting of Experts for the Biological Weapons Convention held from 24-28 August 2009 in Geneva on behalf of the Bioweapons Prevention Project (BWPP) in cooperation with VERTIC.

Verification Quotes

'*Natanz has proved a challenge for agency monitors ... Iran has said they are willing to change how they're operating there*'. Unnamed IAEA official commenting on Iran's decision to allow for more monitoring at Natanz.

'*I didn't get the sense they had a clear, definitive policy direction, but I think they're trying to get one down*'. Unnamed analyst comments on the White House's 13 August 2009 workshop on policies to prevent international biothreats.

'*The Russian side together with its partners believes that the IAEA should look into the matter without delay in the context of the inspection activities regarding Iran's nuclear programme.*'. Russian President Dmitry Medvedev reacts to the presence of a new Iranian uranium enrichment site near the city of Qom.

'*Since testing is not a prerequisite for weapons development, we should not assume that even the most verifiable CTBT regime would simply stop the development of nuclear weapons. [It might only] push competition toward design approaches that do not require testing*'. Chris Ford, a former Bush administration official, seemingly accepting that the CTBT verification regime has progressed, raises new objections.

Verifying a ban of fissile material production

Today's vast stockpiles of fissile material are largely a legacy of the Cold War. The production of fissile material did not fully end until the early 1990s following the fall of the Soviet Union. At present, many hundreds of tons of weapons-usable fissile material remain in storage around the world. Most of the material is in the United States and Russia, although large quantities also remain in China, France and the United Kingdom.

Those nuclear weapon states which have ratified the 1968 Nuclear Non-Proliferation Treaty (NPT), sometimes known as the *de-jure* nuclear weapon states, have ceased production within a non-binding moratorium. However, fissile material production is ongoing in South Asia. There, India and Pakistan are trying to define how much material they think they would need in order to maintain their own deterrence. In these two countries, fissile material control measures are often viewed with suspicion. Some in that region argue that too much transparency in material holdings could expose military weaknesses and that an imbalance in stocks could tilt the military balance in one country's favour.

A binding prohibition for all states on the production of fissile material for weapons purposes would do nothing to reduce already accumulated stocks of material and would consequently help to preserve the status quo in fissile material balances. The impact on general nuclear disarmament from this perspective is limited. In addition, it is often expected that India and Pakistan would opt to produce a comfortable cushion of material before signing any control regime. However, a ban on the production of fissile material for weapons purposes would be more than just symbolism. Under a treaty, no new material can be produced, which means that reductions would be the only lawful change in stockpiles. This is why several statesmen around the world argue that the cut-off treaty is the logical first step towards nuclear abolition.

Over the last twenty years, a large amount of work has been produced on what is known as a Fissile Material Cut-off Treaty, in essence a ban on fissile material for weapons purposes. Most analysts, academics and states tend to agree that it is preferable for this treaty to have a verification regime. A minority continue to argue that verification is not necessary, since the moratorium on the production of fissile material has been in effect for two decades without seemingly being breached. This argument understates the perceived significance of verification of the treaty for some non-nuclear weapon states. For them, verification measures would in effect bring the nuclear-weapon states' obligations closer to those of non-nuclear weapon states thus making the nuclear non-proliferation regime less discriminatory. The minority view also supposes that the nuclear weapon states trust each other well enough to forego verification of compliance, and this is arguably an overstatement.

What verification?

It is generally assumed that verification techniques applicable to the proposed treaty are available off the shelf—those advocating this sometimes claim that the solution is as simple as applying full scope safeguards on the nuclear weapon states. This involves placing verification measures on most nuclear facilities in the country, essentially tracking nuclear material flows from uranium conversion to final disposition. Beyond doubt a workable solution, but is it a necessary one?

After all, while the parties to the cut-off would enter into a commitment similar to that for non-nuclear weapon states under the NPT, several important differences remain. A fissile material cut-off would not alter the nuclear weapon states' right to manufacture, store and deploy nuclear arms. Therefore, large amounts of legitimate fissile material will be present on the territories of the state parties. There is little point in monitoring this pool of material, since the state is free to make use of it as it sees fit. This is an argument in support of the idea that the treaty, and its verification regime, should be focussing on the back-end of the nuclear fuel cycle rather than on the entirety of the fissile material manufacturing line. This is often referred to as a "focussed approach".

In addition, is a full scope approach economically viable? It is certainly possible to safeguard reactors, spent fuel ponds, conversion activities, heavy water production and fuel fabrication facilities. Likewise, it is possible to build a picture of the total production capacity of an individual state (through declarations on associated infrastructure such as uranium mining and milling). However, this is likely to be a human and capital-intensive exercise. By including nuclear weapon states, with their extensive nuclear fuel cycles, conservative budget estimates indicate a doubling, or perhaps even a tripling, of the present IAEA safeguards budget. In addition, given that no one really knows how much material has been produced in the nuclear weapon states (the margin of error in Russian estimates, for instance, hover at around five per cent), it is likely that full scope safeguards would have little marginal utility. It makes more sense to focus the verification effort on nuclear material flows directly relevant for weapons production (that is uranium enrichment, certain conversion activities and spent fuel reprocessing), and to start the accountancy work from a new baseline.

The main prohibition

There is a tendency in the literature to discuss fissile material cut-off verification without linking it to what the cut-off is actually going to prohibit. Papers tend to enumerate 'off-the-shelf' verification techniques and technologies without properly putting them into context. While this is not surprising, the scope of the treaty has after all not been decided, it leads to a confused debate. The usefulness of any verification proposal will necessarily be limited unless there is a clear relationship to the obligation to be verified.

The goal of any verification regime is to determine whether a party is compliant with a defined obligation that it has undertaken. The certainty with which the verification regime can make this determination depends on the clarity and precision of the undertaking itself. It is, for instance, easier to verify that an item remains in its declared place than it is to verify that all items that should have been declared are in fact declared.

The verification regime is a product of the scope of the treaty, not the other way around. The question *what should the system verify* needs to be answered before the verification designer can examine the questions *where to verify*, *when to verify*, *how to verify* and *who should verify*. This poses a problem for anyone examining cut-off verification. Unless the examiner makes a number of assumptions on the scope of the proposed treaty at the outset of his or her examination, he or she would need to propose several alternative verification regimes. Once the examiner has decided on the question *what should be verified*, however, the rest of the exercise becomes relatively straightforward.

Non-compliance scenarios

One can also examine fissile material cut-off treaty verification from a non-compliance perspective. If a state is prohibited from producing these materials, how would it go about cheating on its obligation? There are two notable non-compliance scenarios:

- diverting material from a declared facility; and
- producing material in undeclared facilities.

The first scenario is serious, albeit not very likely. Today's material accountancy and control techniques are adequate for effective verification. There are some problems relating to material accountancy at reprocessing facilities, but somewhat relaxing the timeliness criteria can overcome these. Likewise, a new safeguards approach for uranium enrichment plants is probably necessary to solve some of the accountancy problems at large-scale facilities. These are significant but not insurmountable challenges to a focussed verification regime.

The second scenario poses most challenges under a fissile material control regime. The main problem with a focussed verification approach is that it makes the construction of a clandestine fuel cycle relatively simple.

The focussed approach would, for instance, exclude pre-enrichment conversion of uranium oxide to hexafluoride gas. Consequently, the non-compliant state only needs to construct a clandestine uranium enrichment plant if it desires to resume production. This is not beyond the reach of the recognized nuclear weapon states. And these facilities would be very difficult to detect.

Consider the following scenario. A state wants to construct a clandestine enrichment plant capable of producing enough material for about three basic uranium weapons per year. Here, a plant comprising 400 URENCO TC-16 centrifuges would do the job. The centrifuges would need some 1,200 square meters of floor space to operate, and the total energy consumption to run the machines would be very small. Indeed, the industrial operation would not draw enough energy to distinguish it from any other industrial plant. Consequently, the facility could be hidden in small and non-descript buildings and would be very difficult to detect from the outside. It would have few emissions and would require very little power infrastructure. In fact, it would look more like a warehouse than an industrial site.

What about shipments of material? The plant would only need to be supplied with about 19 metric tonnes of uranium hexafluoride gas per year. This would constitute a diversion of less than 0.3 per cent of the United Kingdom's annual conversion capacity and less than 0.1 per cent of Russia's. The plant could be supplied by trucks, and would therefore only need access to the road network. Access to a rail network would not be required. On the other hand, if pre-enrichment conversion facilities are envisioned to fall under safeguards, the state must either divert the 19 metric tonnes from one of their declared facilities or build a small undeclared conversion facility (with a capacity of some 50 metric tonnes per year) to supply the enrichment plant.

Diverting from a declared facility, where safeguards are applied, entails a risk of detection. Especially since the early 2000s, when the starting point of safeguards was moved from the shipping area to the receipt area of the facility, making it possible to match input with output. By using the 2000 International Target Values for Measurement Uncertainties in Safeguarding Nuclear Materials, one can deduct that the IAEA could detect a diversion of approximately 16 tonnes in a facility capable of handling 6,000 tonnes of natural uranium hexafluoride gas per year (with 90 per cent confidence, a five per cent false alarm rate and assuming use of 14 tonne transport containers)

Building a new conversion facility is also not beyond the capability of any recognized nuclear weapon state, but would increase the financial burden of non-compliance. According to some academics, emissions from conversion facilities could possibly be detected at a significant distance by remote sensors but it is relatively simple to avoid detection by, for instance, co-location with a declared conversion facility. However, this increased risk for detection would factor into the state's non-compliance strategy, and make cheating a bit more burdensome.

Another scenario would involve using a reactor to produce weapons usable plutonium. Since the focussed approach would not involve verification of material balances at reactors *but would* involve the verification of balances at reprocessing facilities, the state would need to construct a clandestine reprocessing facility. Emissions from these facilities can be detected at some distance by remote sensors, but it is again easy to cheat by simple co-location with a declared reprocessing facility.

Challenge inspections

Undeclared nuclear fuel cycles cannot be detected by routine inspections, and the deployment of remote sensors able to detect various plant signatures on the territory of state parties are likely to be highly unpractical. The question is whether to rectify the problem through requiring safeguards on larger swathes of the nuclear fuel cycle (i.e. opting for a full -scope regime) or to implement a challenge or special inspection system to handle suspicions of non-compliance. A challenge inspection regime has weaknesses. Normally, some sort of evidence would be required pointing towards non-compliance in order to get the necessary political support for such inspections. This evidence alone tends to create a presumption of guilt. Related to that, if the challenge inspection fails to produce any evidence due to the absence of undeclared activities, it is quite possible that the requesting state will not be convinced by the outcome. This relates to the well-known problem of proving a negative.

Diminishing returns of verification

How much verification will be enough for the purpose of a fissile material control regime? Sadly, there is no technical answer to this question. Rather, a political judgement by the negotiating parties will decide whether proposed verification measures are adequate to the task. Economic theory can possibly provide some answers. It is reasonable to assume that the marginal benefit of verification measures will decrease with each layer of additional verification (so-called diminishing returns). Even if the marginal cost of deploying an additional layer of verification is constant, there would be a point where the marginal benefit meets the marginal cost. It is possible to envision an optimal verification system, or verification equilibrium, at that point.

The only developments that would shift that equilibrium are the introduction of more effective techniques, hence increasing the marginal benefit of one additional layer of verification, or lower marginal costs. For example, the introduction of so-called integrated safeguards in the IAEA safeguards system aims to maintain the current state of assurance, but at a lower marginal cost, thus increasing the overall utility of the system.

Conclusion

In respect to a fissile material cut-off treaty, the verification designer needs to consider the object and purpose of the regime. Presently, few weapon states would consider a treaty that encompasses reductions in stocks. Rather, the idea is to codify the twenty-year-old fissile material production moratorium already in effect between the *de-jure* nuclear weapon states and to introduce a prohibition on production in *de-facto* nuclear weapon states in South Asia and the Far East. The nuclear weapon states would have little incentive to place their stocks on the negotiation table. After all, it was the accumulation of stocks that made them consider the treaty in the first place. Past production of fissile material is also significant from another angle. Given the large uncertainties in historical production in some weapon states, it will be near impossible to establish baseline inventories of nuclear material. There will not be any meaningful way, consequently, to monitor changes in state inventories of fissile material. This means that a full scope verification regime will yield few benefits on the margin. A focussed approach, simply looking at carefully defined materials, compounds and processes should be sufficient to assure the nuclear weapon states that no militarily significant production of fissile material is occurring. This low-assurance verification scheme will by no means be foolproof, but given the object and purpose of the proposed treaty, it may be viewed as sufficient. It may also reduce costs in treaty implementation.

Andreas Persbo
Acting Executive Director, VERTIC

Verification Watch

CTBT members promote entry into force

On 24 September 2009, 150 foreign ministers issued a declaration calling for the early entry into force of the 1996 Comprehensive Nuclear Test-Ban Treaty. The declaration proclaimed that 'ending all nuclear weapons testing is [a] meaningful step in the realization of a systematic process to achieve nuclear disarmament,' and that ratification to achieve early entry into force was a practical step toward this goal. 44 specific state ratifications are needed for the treaty to come into force. Nine states have yet to ratify.

While the declaration emphasized the importance of the moratorium on nuclear testing, it also stressed that the treaty's entry into force would make the ban permanent and legally binding. Addressing the conference, US Secretary of State Hillary Clinton remarked that entry into force will 'permit the United States and others to challenge states engaged in suspicious testing activities—including the option of calling on-site inspections to be sure that no testing occurs on land, underground, underwater, or in space.' In this context, the declaration called for maintaining momentum in solidifying the treaty's verification regime.

Matthew McGinn, London

UN Security Council passes Resolution 1887

A special session of the UN Security Council gave its unanimous support to a US proposed resolution calling for the worldwide elimination of nuclear weapons. The Council meeting, on 24 September 2009, was chaired by US President Obama. The adopted resolution solidified the Security Council's commitment to implementing measures to reduce, and ultimately eliminate, nuclear arsenals worldwide.

The resolution reaffirmed the use of sanctions on nations that have continued to proliferate weapons. President Obama reaffirmed the Council's commitment to maintaining the legitimacy of international treaties: 'international law is not an empty promise, and treaties must be enforced'. During the discussions, the UN Secretary General, Ban Ki-moon, put emphasis on nuclear-weapon states obligations and called on them to consider new measures by which to decrease and eliminate their nuclear stockpiles, including achieving verifiable disarmament.

The resolution is not intended to be binding on the UN member states, but nevertheless contains very strong guidance on where the Council members would want to take the non-proliferation regime. From the outset, for instance, it emphasizes its primary responsibility in addressing situations of non-compliance with non-proliferation obligations, should such situations be potential threats to international peace and security.

Much of the resolution reads like a wish-list for the arms control community. The resolution calls on those UN member states who have not done so to accede to the 1968 Nuclear Non-Proliferation Treaty as non-nuclear weapon states. It calls on the *de-jure* nuclear weapon states to engage in talks on nuclear disarmament, and urges other states to join in this endeavour. It also calls for the start of negotiations on a fissile material treaty (but fails to mention verification) and it calls on states to sign and ratify the 1996 Comprehensive Nuclear Test Ban Treaty.

Importantly, it strongly supports the strengthened safeguards regime by calling for all member states to sign and ratify comprehensive safeguards agreements and additional protocols with the IAEA. In that context, it stresses the importance of giving the IAEA the necessary resources and authority to do its job.

Finally, it reaffirms the need for full implementation of UN Security Council Resolution 1540. As *Trust & Verify* went to press, the comprehensive review of this resolution was well underway in New York.

Matthew McGinn, London

START successor to include verification

Russia and the United States have agreed that the follow-up to the 1991 Strategic Arms Reduction Treaty (START) will include a significant verification regime as a critical part of its implementation. The previous US administration was opposed to such measures. This is an important development in maintaining and increasing the role of verification procedures as a critical part of nuclear disarmament.

One shortcoming, however, is the fact that Tactical Nuclear Weapons (TNW's) continue to be ignored as part of modern reduction efforts. TNW's are the primary method by which any nuclear warhead would be delivered in a modern nuclear conflict and considerably blunts any warhead reduction treaty. The only bilateral TNW treaty between Russia and the US remains the 1987 Intermediate-Range Nuclear Forces Treaty (INF). Both Washington and Moscow have been discouraged from working on new TNW treaties due to, amongst other things, the difficulties in establishing effective verification regimes for such agreements. Russia has also threatened to abrogate from its INF obligation if it is not internationalized, meaning that it is now more critical than ever to develop effective verification and inspection procedures for this purpose.

Nevertheless, the new treaty is expected to increase the importance of verification procedures. The START-I treaty had already established verification as a critical aspect of arms reduction treaties, but these verification measures had focused primarily on delivery methods such as ballistic missiles. Methods include on-site inspections and national technical means. It is hoped that the new treaty will equally extend to the verified disarmament of both warheads and delivery vehicles thus increasing the effectiveness and confidence-building effects of this new important initiative.

Anis Cassar, London

Director-General of the OPCW highlights successes and challenges of verification

On 5 August 2009, the Director-General of the Organisation for the Prohibition of Chemical Weapons (OPCW) addressed the International Union of Pure and Applied Chemistry (IUPAC) in Glasgow.

Director-General Pfirter stated that the OPCW has successfully verified the destruction of 46 per cent of all declared chemical warfare agents. He also noted that 94 per cent of all facilities which previously produced chemical weapons have either been destroyed or converted to peaceful uses.

Mr. Pfirter stressed, however, that with half the declared stockpiles remaining, the international community must redouble its efforts to meet the challenge of verifying complete global elimination by the legally mandated deadline of 12 April 2012. He stated that work remains to be done in ensuring a comprehensive verification regime, not only of the dismantlement of chemical weapons, but also in terms of prohibiting proliferation. In this regard he pointed to the importance of industry verification protocols, and stated that the OPCW has already carried out over 1,600 such inspections in over 80 states. There are approximately 5,000 industrial facilities worldwide which could potentially be involved in chemical weapons proliferation, and he noted the challenges involved in maintaining continued assurance against non-proliferation when faced with this number of sites.

Mr. Pfirter emphasised that aiding states to adopt national legislation reforms which comply with international legal definitions and provisions can help address new proliferation threats, such as those posed by non-state actors. He also pointed to UN Security Council Resolution 1540, which obliges all UN member states to adopt legislative and administrative means to prohibit the proliferation of chemical weapons.

Anis Cassar, London

Russia destroys first ton of Sarin gas

Russian and international media have reported that Russia has successfully destroyed its first ton of Sarin gas at its Maradykovsky facility in the Kirov region. The process, which began on 27 July 2009, is the first step in Moscow's destruction of all 231 declared tons of the fatal nerve gas. The Maradykovsky facility has stored over 40,000 Sarin bombs and warheads over the past half century. The destruction of the weapons is being overseen by several international groups, including the UN and the OPCW. This latest development forms part of Moscow's pledge to eliminate its chemical weapons stockpiles by 2012.

Anis Cassar, London

Montreal Protocol becomes universal

Timor-Leste's ratification of the Montreal Protocol in September makes it the first treaty to receive universal support from all 196 UN member states. The Montreal Protocol prescribes the incremental phasing-out of various chemicals which degrade the ozone layer. The UN Environment Programme reports that by the end of the year, the treaty will have retired the use of around 100 chemicals which have been linked to ozone depletion.

The Montreal Protocol is generally considered to be one of the most successful environmental agreements to date. It is estimated that it has prevented a significant number of cancer cases as well as damage to human immune systems. The phasing out of these gases also helps to combat climate change.

Anis Cassar, London

Preparations for Copenhagen Conference

With less than 14 official negotiating days in the three remaining months before the Copenhagen Climate Change Conference, it is clear to all that a great deal of work remains to done, both in the run up to and during the meeting. Although the largest emitting nations and economies have provided some positive interventions at forums like the UN's Climate Change Summit in September, considerable progress needs to be made before agreement can be reached on the substance and structure of key elements of the package. Discussions are focusing on emissions targets, and other mitigation actions, adaptation measures, technology transfer and financing mechanisms. Mechanisms to reduce emissions from deforestation and degradation will also be a major topic. As well as agreeing on figures for targets and financing levels, the regime also needs to consider the frameworks and procedures for implementing these mechanisms, including monitoring, review and verification (MRV) systems. Agreeing on effective and comprehensive MRV systems, and making sure they are efficient and fair, will play a fundamental part in building a workable treaty.

Larry MacFaul, London

New agreement to stop illegal fishing

In September 2009, a group of 91 states signed an agreement aimed at fighting illegal fishing. The agreement will introduce a number of new regulatory and enforcement measures for states to adopt into their maritime codes and procedures. The 'Agreement on Port State Measures to Prevent, Deter, and Eliminate Illegal, Unreported and Unregulated Fishing' is the first such measure to achieve this level of international consensus . The agreement contains several 'port-measures' aimed at disrupting illegal fishing activities. These measures include a commitment by states to require foreign fishing vessels to make declarations on their identity and details of what catch they have on board, before granting them authorization to enter their ports. This will make it easier for authorities to corroborate or investigate the legality of the fishing vessel's operations. States have also committed to making regular fishing-vessel inspections, for which the agreement provides guidelines. Countries have also committed to provide adequate training for inspectors. To the extent possible, inspections are to include verification of vessel identification documentation, fishing authorizations and other relevant documentation. The inspections should also verify both that the catch was harvested according to the authorization and that the fishing gear also conforms to conditions in the permit. Moreover, if a vessel is denied access, this information is to be communicated, if possible, to relevant coastal states, and international organizations, among others, and the flag state must take action. The treaty also contains a range of other provisions to support action in this area as documented in the chairperson's draft agreement on port state measures to prevent, deter and eliminate illegal, unreported and unregulated fishing.

The problem of illegal, unreported and unregulated fishing has serious effects on international efforts to sustainably manage fishing stocks. The agreement is to pass through various UN Food and Agriculture Organization procedures and will then have to be ratified by at least 25 of the signatory states before it comes into force.

Anis Cassar, London

ElBaradei's final general conference

It is an economic law that one way to increase supply is to reduce marginal costs. For many years, the IAEA has been forced to do just this. Outgoing Director-General ElBaradei's statement to his last General Conference, that safeguards have undergone a 'transformation' should be read in this light. He pointed out that the Agency has 'moved beyond simple verification of declared nuclear material at declared facilities to assessing information on a State´s entire nuclear programme and, most importantly, verifying the absence of undeclared activities'.

Dr ElBaradei pointed out that 'universal adherence by all non-nuclear weapon states to comprehensive safeguards agreements and additional protocols is a prerequisite for an effective verification and non-proliferation system.' This is something the IAEA has been pushing since the early 1990s. The Additional Protocol is important since it represents the move from an accountancy-based safeguards system to an information driven safeguards regime.

Dr ElBaradei wants to go further, however. In his speech, he pointed towards a gap in the safeguards regime, 'although the Agency´s verification mandate is centred on nuclear material, to preclude the possibility of undeclared nuclear material and activities in a country, it may be necessary for us to pursue alleged weaponization activities'. Investigations into weaponization cannot be made through accountancy methods, which means that the IAEA needs to employ measures similar to those used by law enforcement: interviews, forensics and reliance on member state supplied intelligence.

Intrusive investigations lead to controversy. Dr ElBaradei highlighted that 'we must let diplomacy and thorough verification take their course, however lengthy and tiresome the process might be. We need to carefully assess the veracity of intelligence information so as not to let verification turn into a witch hunt.' The latter point is particularly important, and relates both to the way the IAEA preserves its independence and the way the organisation handles potentially sensitive information.

Evidence collection, collation and analysis requires straddling a fine line between sharing and withholding information from the outside world. The key is to ensure a strict chain of custody of collected information and, naturally, to refuse outside influence when it is time to draw conclusions. So far, the IAEA has managed to maintain its impartiality, but it cannot allow itself to lower its guard.

Finally, the Director-General pointed out that the IAEA cannot do its job in isolation. It has to have proper backing by the UN Security Council. Dr ElBaradei identified the problem: 'The Council needs to develop a comprehensive compliance mechanism that does not rely only on sanctions, which too often hurt the vulnerable and the innocent'. But a solution to this problem has yet to be provided.

Ambassador Yukiya Amano, the incoming Director-General, also mentioned safeguards in his inaugural address to the General Conference. His speech was understandably more measured but the IAEA community will likely hear more from Ambassador Amano at the 54th General Conference in Vienna next year.

Andreas Persbo, Vienna

Science & Technology Scan

NASA to decide on future of OCO satellite

NASA is to meet in the coming months to decide on the future of the Orbiting Carbon Observatory (OCO) satellite programme. The OCO satellite, designed to be a highly accurate orbiting platform for measuring CO_2 emissions, failed to launch successfully earlier this year and crashed into the ocean near Antarctica. The much anticipated satellite, which was built at a cost of US$273m, was designed to measure CO_2 levels in unprecedented detail. The OCO would have helped to monitor CO_2 'sources and sinks' and greatly improve the understanding of the carbon cycle.

The OCO design measures the entire atmospheric column within its target range, including at low altitudes, using precision spectrometers which can distinguish 17,000 different colours. This allows scientists to detect and measure the geographic origins of carbon emissions and identify sources and sinks. The OCO has the lowest degree of CO_2 uncertainty in its measurements (1-2 ppm), compared to satellites currently in orbit and can take up to 500,000 samples per day. OCO was designed to be able to revisit an original area of study every 16 days (233 orbits). This would allow it to regularly monitor patterns of carbon emissions in any given area and provide a better understanding of carbon cycles.

Satellites, such as the OCO, can greatly enhance atmospheric carbon measuring capacity by providing additional levels of accuracy and geographical coverage to measurements from ground stations. NASA is expected to make a decision in the coming months on the future of the OCO project and whether a new satellite will be rebuilt.

Anis Cassar, London

VERTIC News & Events

Arms Control and Disarmament

In July, the Arms Control and Disarmament Programme continued to focus on nuclear issues. This included participation in one informal consultation on Iran, as well as a number of public meetings. In particular, VERTIC staff enjoyed an informal lunch with White House non-proliferation tsar Gary Samore at the IISS on 9 July 2009.

On 24-25 August 2009, the programme presented some of its work at a workshop organized by the James Martin Centre for Nonproliferation Studies. In addition, the programme presented preliminary conclusions on Fissile Material Cut-Off verification to the Conference on Disarmament on 21 August 2009.

The programme was invited to deliver the keynote address to the 2009 session of the NEA/IAEA International School of Nuclear Law at the University of Montpellier on 31 August 2009.

In September, the programme presented its work to the 53rd IAEA General Conference. The programme fielded a delegation of three to handle a large number of bilateral meetings, as well as keeping an eye on the conference proceedings.

The programme was also represented at a seminar on nuclear non-proliferation and disarmament at No. 10 Downing Street on 16 September 2009.

Andreas Persbo, Hassan Elbahtimy and Jasper Pandza

National Implementation

In August, NIM staff travelled to Geneva to attend the 2009 BWC Meeting of Experts. During the Conference, VERTIC hosted an informal breakfast session—providing the opportunity for discussions with delegations—and delivered a statement outlining the progress made under the NIM Programme over the last few months. VERTIC staff also had several successful bilateral discussions with delegations in the margins of the meeting.

Together with the Stanley Foundation and other organizations, VERTIC is co-organizing the event 'Resolution 1540: At the Crossroads' which will be held 1 October 2009, at the UN Headquarters in New York. This seminar aims to contribute to the official Comprehensive Review of the Status of Implementation on Resolution 1540, conducted by the 1540 Committee. For more details please visit: http://www.stanleyfoundation.org/articles.cfm?ID=592.

VERTIC will discuss the results of an event, (including a final report), co-hosted with the Clingendael Institute in March 2009, on greater technical co-operation and co-ordination among the WMD regimes and the 1540 Committee.

NIM staff also participated in several other events: the UNSCR 1540 Committee awareness-raising workshop, held in Costa Rica in September (for the Central America region); and at a BWC Regional Awareness Raising Seminar and Capacity-Building Workshop in Astana, Kazakhstan. Several countries liaised with VERTIC staff during these workshops to discuss approaches and further co-operation on strengthening their legislation for implementation of the BWC and Resolution 1540.

VERTIC's Factsheet number 10, providing guidance on the establishment or designation of a BWC National Authority, has now been made available in Russian (in addition to existing versions in English, French and Spanish), thanks to kind assistance from the Global Partnership Programme, Foreign Affairs and International Trade, Canada. VERTIC is now in the process of having it translated into Arabic, completing the full set of NIM Programme documents in five languages.

Angela Woodward, Scott Spence and Rocio Escauriaza-Leal

Environment

The Environment Programme continued its work on measuring progress on illegal logging with Chatham House. It revised the project's policy assessment frameworks, based on lessons learned from the pilot phase (completed in June). Full phase work moved to coordinating partners' research activities around the world, including in South-East Asia, Africa and elsewhere, as well as beginning to conduct further research in Europe.

VERTIC and other project coordinators met with another research institute to discuss experiences in conducting forest governance studies. VERTIC also attended the 'Rights & Resources Initiative and Chatham House Dialogue on Forests, Governance & Climate Change', Royal Society, London, 8 July.

It also participated in the 'REDDnet' programme roundtable at the Overseas Development Institute, London, 13 July, to discuss socio-economic implications of reducing emissions from deforestation and degradation (REDD). The programme investigated further opportunities to work on climate change and linking REDD, forest governance and monitoring issues.

Larry MacFaul

Grants & Administration

VERTIC has successfully concluded a contract with the Norwegian Radiological Protection Authority (NRPA) covering the first phase of the UK-Norway Initiative. VERTIC is looking forward to negotiating a new grant with the NRPA for the next phase of this important project.

In September, Matthew McGinn, a Master's student from the Maxwell School of Syracuse University, New York, started his internship at VERTIC. He will be with us for a 3 month period.

Anis Cassar will finish his internship at the end of September. Anis has been an outstanding intern and we would like to thank him for his contribution to VERTIC.

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building trust through verification

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