V&I

VERIFICATION & IMPLEMENTATION

A biennial collection of analysis on international agreements for security and development

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ABOUT VERTIC

The Verification Research, Training and Information Centre is an independent, not-for-profit non-governmental organisation. Our mission is to support the development, implementation and effectiveness of international agreements and related regional and national initiatives. We focus on agreements and initiatives in the areas of arms control, disarmament and the environment, with particular attention to issues of monitoring, review and verification.

VERTIC conducts research and analysis and provides expert advice and information to governments and other stakeholders. We also provide support through capacity building, training, legislative assistance and cooperation.

We engage closely with governments, policy-makers and international organisations, as well as with the private sector and technical, academic and non-governmental communities worldwide.

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FOREWORD

Ahmet Üzümcü

Ten years ago, my predecessor Rogelio Pfirter wrote a preface for this journal's predecessor, the *Verification Yearbook.* He outlined the main requirements for an effective verification regime: that it should be technically sound, effective and efficient, and non-discriminatory. He underlined the need for universality, if the Chemical Weapons Convention (CWC) is to achieve its goals. And he emphasised the unique spirit of cooperation and consensus that defined the CWC.

Rogelio Pfirter's words ring as true now as they did then, and they continue to faithfully describe the CWC's successes and what the OPCW, as its implementing body, seeks to achieve. But it is worth casting a backward glance to see how much has changed for the CWC and the OPCW since 2004, and how our verification regime has successfully weathered these changes. Over that time, the CWC has grown from 164 states parties to 190 today. In 2004, 12 per cent of globally declared chemical weapons had been destroyed under strict OPCW verification; now, that figure is over 86 per cent. In the first seven years of the OPCW's existence until 2004, the organisation conducted around 700 inspections in industrial facilities around the world; since then, we have carried out over 2000 more inspections.

Over the same period the global taboo against the use of chemical weapons has grown ever stronger. At no time has this been more forcefully acknowledged than in the international reaction to the chemical attacks in the Damascus suburb of Ghouta in August 2013. Those horrific attacks led to a series of extraordinary events, including the accession of Syria to the CWC, and the unprecedented mission to remove and destroy its chemical weapons. The fact that these developments took place in the midst of a civil war and in an extremely short timeframe attests to the strength of the international community's determination to seize a rare opportunity to destroy a major arsenal of a weapon of mass destruction, and to further entrench the norm against chemical weapons that the CWC enshrined almost 20 years ago. But it also confirmed that the OPCW—through its particular expertise and experience and, on this occasion, in partnership with the United Nations—was uniquely placed to meet the challenge of eliminating Syria's chemical weapons.

We are continuing to reflect on our experiences in Syria and to learn from them in order to better position the organisation for similar challenges in the future. Certainly, in the course of this mission, we have shown—through our contingency planning, our fully subscribed funding and technical assistance base, our well-coordinated partnerships, our technical innovations and our effective public-private initiatives—that the OPCW has an important role to play in confronting some of the defining security issues of our times. The award of the 2013 Nobel Peace Prize to the OPCW recognised this record of achievement and spurred us on to achieve even greater successes.

This year, 100 years after the first large-scale attacks with chemical weapons near Leper in April 1915, is one of deep significance for the OPCW. Although our organisation is only 17 years old, the legacy on which it builds can be traced back to much earlier efforts to control chemical weapons, both before and after the worst excesses of World War I, and it is the memory of the victims of chemical weapons over the last century that will continue to inspire our work. Implementing the CWC's verification regime is the core task of the OPCW, and in the next few years we will have completed the most visible part of that task: getting rid of the world's declared stockpiles of chemical weapons. But, importantly, the work of making those disarmament gains permanent will continue.

The industry verification system which the OPCW oversees is the most comprehensive in the history of multilateral disarmament and arms control, and it lies at the very heart of our non-proliferation mandate. Its record of success stands on its own, but we cannot afford to be complacent about its ability to detect and respond to future threats. The globalisation of the chemical industry, the rapid development of digital communications, and advances in science and technology are all strategic challenges which the OPCW must address in order to safeguard the trust and confidence in the CWC's verification regime that we have worked so hard to build. The work of universalising the treaty must continue, for it is only through universal adherence that the CWC's vision of a world free of chemical weapons will be realised. And threats posed by terrorist groups, which the verification system was not specifically designed to deal with, cannot be ignored.

These are all significant challenges, but I believe that we can, for the most part, turn them into opportunities. The reason for my optimism is that the Chemical Weapons Convention is a comprehensive and holistic regime that draws its strength from multiple stakeholders. Scientists and industry representatives have been active in the life of the CWC from the very beginning of negotiations on its scope and text. We must continue to draw on their experience and expertise in order to safeguard the gains we have made and to shape our future agenda. Equally, we must continue to enhance collaboration with our states parties, and empower those with economies in transition, to realise the promise of the peaceful uses of modern science, including by making our laboratory facilities available to scientists from around the world.

The unique sense of partnership with which the CWC is imbued will continue to inspire us to explore new ways of implementing our mandate. Our aim is to build on a 17-year record of success by increasing our efficiency and broadening our reach. This not only means staying abreast of scientific and technological advances that may test available mechanisms for implementing the Convention. It also requires us to ensure that we are engaging with all those who have a stake in our mission and making our goal a commonly held one. For that reason, our education and outreach efforts will take on a new dimension and urgency in the post-destruction phase. The OPCW will work to expand and diversify cooperation with science and industry to ensure we are always achieving best practice for our gold-standard verification regime.

To this end, we are working now to bolster our links with regional and international organisations, as well as chemical industry associations, the private sector, academia, and civil society. We will look to make the best possible use of advances in communications technologies to enhance and future-proof our verification system. In doing so, we will work hand-in-hand with our states parties. This will include exploring how technological advances could potentially help the organisation and states parties to further improve our ability to track exports of dual-use goods and materials, to ensure that these goods go where they are supposed to go, and are used for purposes they are intended to be used for. We will continue to modernise our systems of communication with our states parties, including through the roll-out of our new Secure Information Exchange system, which allows the near real-time exchange of confidential verification-related information between states parties and the Technical Secretariat. Through this work, we can realise other benefits, such as helping to prevent non-state actors from gaining access to dual-use materials and know-how.

Strengthening our links with other international organisations will be crucial as we look to the future. The United Nations is central in this regard, whether in partnership on the ground in Syria, or in our broader, mutually reinforcing efforts to promote disarmament. We are likewise engaging regional organisations to use their forums and networks for raising awareness of the goals of the CWC, including in advancing universality. Our interaction with specialised international agencies is usefully identifying areas of overlap that enhance chemical security, ranging from addressing transnational crime and terrorism, to building capacity for chemical emergency response. Finally, we are working with other arms control treaty organisations to exchange best practices in areas ranging from dual-use challenges to verification methods. Institutional cooperation is the bedrock of the broader stakeholder engagement on which the OPCW prides itself.

As we adapt to respond to these challenges, with an increasing focus on the OPCW's non-proliferation mandate over coming years, it is vitally important that the organisation remains the pre-eminent international repository of expertise on chemical weapons. This will be crucial for allowing us not only to deal with legacy chemical weapons, such as those that continue to be found in the sea or on the former battlefields of Europe and Asia, but also to respond, as the CWC mandates, should chemical weapons ever be used again. We will equally draw on this unique technical expertise—built and maintained through our core verification work, whether in the field or in our laboratory—to render assistance to our states parties as they continue to implement the CWC in the years ahead.

To be able to deliver in all of these areas, the OPCW must constantly ensure that its resources—both human and material—are fit for purpose and able to deal with the exigencies of our mandate. The shift in the organisation's focus over the next few years, as well as the strategic challenges I have described above, will necessitate a close re-evaluation of how we deploy those resources to maximise the value we provide to our states parties and to international security as a whole. That process is now well underway.

The success of the OPCW over its 17-year history has been something of a poster-child for verification in multilateral disarmament and arms control. The challenge for us now is to build on this success through collaboration, innovation and leadership. I am confident that the strength and diversity of our partnerships within an ever broadening community of stakeholders will help us source new and better solutions to new and existing challenges. At the same time, the OPCW will continue to be a leader in sharing its considerable knowledge and experience in this vital area of disarmament and non-proliferation. Our common aim must be to ensure that all disarmament efforts can make a durable contribution to global peace and security.

H.E. Mr Ahmet Üzümcü is the Director-General of the Organisation for the Prohibition of Chemical Weapons, The Hague, Netherlands.

PREFACE

Larry MacFaul

In 2015, the world is facing a formidable series of security challenges. These include the ongoing existence of nuclear arsenals, the recent use of chemical weapons, and the risks presented by an evolving biotechnology industry. They also include the illicit and uncontrolled spread of conventional weapons, terrorism, and instability caused by conflict, natural resource stress and disease. International tensions and uncertainties are mirrored at the new frontiers of cyberspace and outer space. Emerging technologies may provide novel solutions to these issues, but they will almost certainly present new challenges to international peace and security too.

The existing framework of international treaties and agreements provides a powerful tool for overcoming these challenges. The implementation, monitoring, and verification of these arrangements builds confidence and know-how, allowing the international community to work collectively toward mutual security. Innovative approaches to verification and implementation that draw on technical, legal, political and economic insights will help achieve this goal.

The opaque and uncontrolled spread of conventional and unconventional weapons around the world can lead to human rights abuses, fuel conflicts, encourage arms races, and foster instability between states. Demonstrating and supporting the implementation of initiatives that reduce these threats—such as the Arms Trade Treaty, the Biological and Toxic Weapons Convention, the Chemical Weapons Convention, and the Nuclear Non-Proliferation Treaty—provides states with the confidence they need to restrain their own defence activities and capabilities.

Mutual security also depends on sustainable development, and the maintenance of the complex natural resource systems on which states rely. Implementing the international initiatives that aim to repair or prevent damage to these resource systems, and demonstrating this through monitoring and verification, supports collective action by recognising states that are meeting their obligations and identifying those that are not. Moreover, monitoring systems in this field can provide essential information on the nature and extent of states' actions on the problem being addressed. They provide a feed-back loop allowing governments and citizens to review and revise their actions accordingly.

International treaties and agreements cover a diverse set of aims and issues, and the activities they control are therefore similarly diverse. That being said, most agreements revolve around similar principles of monitoring and verification. They also often require, or encourage, parties to put in place a legislative framework that will provide domestic guidance on how their obligations will be met, and a legal backbone to support this.

Nurturing a wide range of technical, legal, political and economic tools will help the international community support cooperative approaches to shared security challenges. Tackling these challenges requires a sound appreciation of the interests of governments and other stakeholders, and how they interact with one another. It requires identifying the approaches that worked in the past and those that did not, and how verification and implementation systems should evolve to remain efficient and effective. And assistance must be made available to governments and other stakeholders who might otherwise struggle to participate in collective approaches to security to the extent they would like.

These issues are being addressed by a wide and multidisciplinary community of organisations and individuals committed to finding ways of galvanising and sustainaining purposeful collective action toward a more peaceful and productive future.

In this context, VERTIC is re-launching its book series focusing on international agreements for global security and development. This publication presents an accessible set of essays, authored by leading practitioners and experts from the community, that explain and appraise the verification and national implementation mechanisms that make international arrangements work in practice. The essays also throw light on how emerging developments in technology, industry, business and society around the world may impact this field, both in terms of new risks to international agreements, and new opportunities to strengthen them. While the essays contained here typically take an interdisciplinary approach to their subjects, some turn their focus towards one particular perspective—be it legal, political, or technical.

We have made a number of changes to the previous book series. These include publishing every two years, rather than annually; renaming the publication as *Verification & Implementation;* and applying a peer review process to the chapters to complement our normal review procedures.

Readers of this publication will find practical analysis of verification and implementation issues that can assist them in addressing or researching current challenges faced by the international community. The series serves as a useful reference tool for a wide range of stakeholders including practitioners, political decision-makers, diplomats, government officials, scientists, lawyers, the media, students and the private sector.

Chapters one and two focus on a key international security event of recent times; the Joint Comprehensive Plan of Action (JCPOA) between Iran, the P5+1, and the EU—which was concluded in July 2015 after many twists and turns. The first chapter—'Iran and the evolution of safeguards' by Mark Hibbs—analyses how the evolving International Atomic Energy Agency nuclear safeguards system, which verifies states' non-proliferation commitments, has coped with Iran's nuclear activities and argues that the deal's implementation will be a critical test case for multilateral nuclear verification and the nuclear non-proliferation regime more broadly. The second chapter—'Securing Iran's front end' by Andreas Persbo—complements the first by discussing how the verification goals and arrangements agreed under the deal address Iran's uranium mining and milling capacity (the 'front end' of the nuclear fuel cycle). It examines these arrangements in the light of potential diversion scenarios, discusses how specific verification methods could be applied—including by using novel technology—and how such methods may relate to the development of IAEA safeguards in the longer term.

Chapters three and four widen the scope of discussion on international nuclear agreements. 'In defence of the evolution of safeguards' by Craig Everton examines the 'state level concept' in the development of IAEA safeguards, and argues that while there is a perception that the processes underpinning this concept represents something fundamentally new, it is rather concerned with making more effective use of the adaptability already provided for. 'Organisational culture for safety, security and safeguards (3S) in new nuclear power countries' by Don Kovacic focuses on how states can improve efficiency and effectiveness by integrating the organisational cultures of nuclear safety, security and safeguards. It cautions that there is currently no widely accepted understanding of what is meant by a nonproliferation culture, and suggests that the international community, and in particular countries with mature nuclear power programmes, should collaborate with newcomer countries to tackle non-proliferation needs.

Chapters five and six move on from nuclear safeguards to concentrate on other forms of nuclear verification. 'Investigating multilateral verification of nuclear disarmament: fuel cycle modelling for simulations' by David Keir and Russell Moul presents a methodology for modelling nuclear fuel cycles in notional nuclear-armed states. These models will provide baseline data for the development of verification solutions and also educational simulations. 'Dealing with Objections to the CTBT' by Ed Ifft gives a US perspective on the political, legal and technical issues currently surrounding the Comprehensive Nuclear Test-Ban Treaty and addresses four objections to entry into force: verification, weapons stockpiles, relevance to non-proliferation and definitions.

The latter half of the publication moves away from the nuclear field to discuss important developments in international efforts to tackle chemical weapons and progress in implementing the Biological Weapons Convention. It also presents an analysis of the genesis of a major new conventional arms treaty and a broad discussion of security in the new domain of cyber space.

Chapter seven presents a record of a major undertaking of our time carried out by the Organisation for the Prohibition of Chemical Weapons (OPCW). 'Chemical demilitarisation in Syria: an overview' by Dominique Anelli and Mehran Rouzbahani provides an account of the demilitarisation process in Syria, through facts, figures and official decisions. It details the types of chemicals involved, how they were processed, what equipment and vessels were used, and the involvement of several countries and commerical bodies in addition to the central role of the OPCW itself.

Chapter eight by Angela Woodward focuses on the 'Biological Weapons Convention: implementing legislation and compliance'. The chapter notes that, in the absence of a verification regime for the convention, proposals to enhance transparency and build confidence in compliance put national legislation in the spotlight. The chapter discusses the legislative implementation requirements of the convention, suggests that different models of legislative compliance will be necessary, and gives a précis of the confidence-building proposals in this area.

Chapter nine 'The Arms Trade Treaty: making a difference' by Jo Adamson OBE and Guy Pollard MBE provides the historical context for the treaty from events early in the last century, through to the Cold War, recent regional and domestic conflicts, to the present day. The chapter charts how the momentum for developing the treaty was built through a coalition of NGOs and champion states. It notes that its entry into force demonstrates the power of international cooperation and argues that if the treaty is properly implemented 'it has the capacity to lead to a better regulated international trade, choke supply to the illicit market and evolve over time to keep pace with new developments.'

The final chapter in this volume focuses on a new and influential domain of international cooperation and conflict: cyber space. 'Fundamentals of Cyber Security', by David Clemente provides a foundational examination of this domain and of the challenges and opportunities for international cooperation within it. The chapter discusses the roles and capacities of the public and private sectors in general, and also considers the divergent positions and interests of several governments across the world. The chapter highlights the problem of attribution online, and its impact on attempts to develop and verify international agreements in this area. It concludes by noting that there is still much work to be done to harness the opportunities of cyberspace while understanding and minimising its dangers.

VERTIC would like to extend a very warm thanks to H.E. Mr Ahmet Üzümcü, Director-General, OPCW, for kindly providing the foreword to this book; all the authors for their dedication when contributing chapters to the volume; and to the reviewers, whose comments and suggestions have been invaluable. In addition, we wish to express our gratitude to Rick Jones, designer and typesetter, and Doug Draper at 3G Evolution Ltd for their efforts in producing this book.

Larry MacFaul is the Editor of *Verification & Implementation* and Acting Director of the Verification & Monitoring Programme at VERTIC.

CHAPTER 1

Iran and the evolution of safeguards

Mark Hibbs

Introduction

In February 2003, the International Atomic Energy Agency (IAEA) confirmed that the Islamic Republic of Iran had secretly developed the technical basis for an industrial-scale uranium enrichment programme using gas centrifuges. Shortly thereafter the IAEA determined that a deliberate Iranian 'policy of concealment' systematically deceived the IAEA for twenty years about the scope of Iran's nuclear activities. These activities included undeclared uranium enrichment and plutonium separation, in contravention of Iran's bilateral safeguards agreement with the agency.[1]

These findings prompted a comprehensive IAEA investigation into Iran's ongoing and past nuclear activities, and thrust Iran into the international nuclear verification spotlight where it has remained ever since. To the extent that the IAEA's Iran probe concerned the actions of a fully sovereign state it was also unprecedented.[2] IAEA verification in Iran intensified following disclosure of Iran's transgressions, while on a parallel track Iran negotiated with the United Nations Security Council and the IAEA Board of Governors about the future of its nuclear programme.

On July 14, 2015, Iran and six countries—China, France, Germany, the Russian Federation, the United Kingdom, and the United States—concluded a Joint Comprehensive Plan of Action (JCPOA) meant to resolve the Iran nuclear crisis. In the coming years the implementation of the JCPOA will be the single most important test case for the success or failure of multilateral nuclear verification and, beyond that, the nuclear non-proliferation regime.

The Iran nuclear crisis challenged the IAEA at a critical time in the evolution of its safeguards system. Five years before, the IAEA had established the Model Additional Protocol (MAP), providing the IAEA complementary legal authority to verify states' safeguards obligations and detect activities like those Iran had concealed. The MAP was the centrepiece of a strategic reorientation underway at the IAEA since the early 1990s to rely less on routine accounting of nuclear material and activities declared to the IAEA by states, and instead to design safeguards activities in each state on the basis of proliferation risks identified by an analysis of that state's entire and unique nuclear profile. Between 2002 and 2004, while IAEA inspectors and analysts learned of Iran's hitherto undisclosed nuclear activities, the agency's safeguards planning staff adopted the label 'state-level' safeguards to underscore the IAEA's focus on the country as a whole, as distinct from its individual nuclear facilities and inventories.[3] In response to revelations about Iran's nuclear programme, the IAEA has applied elements of a 'state-level approach' (SLA) for safeguards in Iran.

More recently, a number of IAEA member states have expressed reservations about the IAEA's 'state-level concept' (SLC) for safeguards. Some went on record saying that they would not support the SLC if it imposed additional or arbitrary obligations. Russia especially urged that the IAEA not encroach on states' sovereign rights as expressed in bilateral safeguards agreements. Consistent with Russian positions on the SLC, three years later Russian negotiators in 2015 insisted that the text of JCPOA should expressly underscore that 'All provisions and measures . . . should not be considered as setting precedents for any other state.'[4]

Russia's concerns notwithstanding, Western state parties to the JCPOA favour incorporating provisions of the agreement that go beyond existing obligations formally expressed by states' comprehensive safeguards agreements (CSA) and Additional Protocols (AP), into a global 'enhanced verification standard.'[5] Should they try to universalise these provisions, it can be assumed that others will not agree, and thereby continue longstanding debate over how IAEA safeguards should be conceptualised, further developed, and implemented.

Beginning in 2014, the IAEA has more actively engaged member states to develop confidence in the SLC. Untroubled implementation of the JCPOA would also encourage states to conclude that the IAEA's safeguards concept is sound. Should implementation of the JCPOA instead become adversarial, discussion between states and the IAEA over safeguards would likely become more contentious.

Iran's safeguards obligations

Iran's nuclear programme began in the 1950s. Until the revolution in 1979 toppled Mohammad Reza Shah Pahlavi, Iran's fledgling nuclear activities resembled those in many countries that relied on assistance from advanced countries. Iran promptly joined the IAEA in 1959 and the Nuclear Nonproliferation Treaty (NPT) in 1970, and it concluded an NPT safeguards agreement in 1974.[6] The Shah made ambitious plans for future nuclear power development, but when he was ousted, Iran had no infrastructure to produce direct-use nuclear materials.[7] Twenty-four years later, however, the IAEA learned that, shortly after the Islamic Republic was established, Iran significantly accelerated the scope and extent of its nuclear activities.

Iran is one of 186 non-nuclear-weapon state parties to the NPT. Iran has a CSA that is based on the IAEA's document INFCIRC/153 (Corr.).[8] Following from NPT

Article III, Iran's CSA obligates it 'to accept safeguards . . . on all source or special fissionable material . . . for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices.' Iran is also obligated to cooperate with the IAEA in facilitating the implementation of safeguards pursuant to the safeguards agreement.[9] When Iran's hidden activities were revealed in 2003, Iran had not concluded an AP.

The most important IAEA policy-making body is its board of governors, consisting of 35 member states. In September 2003, in response to findings of extensive safeguards violations by Iran, the board passed a resolution which, *inter alia*, requested the IAEA Secretariat to report to the board on safeguards implementation in Iran within three months.[10] This resolution set in motion an IAEA investigation into Iran's nuclear activities that, 12 years later, is still in progress.

What is known in the public domain about Iran's nuclear history has been provided by the IAEA Secretariat in quarterly reports submitted to the board of governors since June 2003, based on its own findings and other sources. These reports provide an accounting of the IAEA's record of investigating and verifying Iran's nuclear activities from 2003 to the present.[11]

Political and verification contexts

Iran was not the first case where the IAEA found that a state had violated an NPT safeguards agreement. The most serious transgressions led to non-compliance findings by the board of governors in Iraq in 1991 and North Korea in 1993. Each of these cases was unique but in both nuclear activities were concealed from the IAEA in violation of states' obligations.

The political context

The IAEA confirmed the existence of a uranium enrichment plant site in Iran four weeks before the United States launched what would become a discredited 'war of non-proliferation' against Saddam Hussein's Iraq.[12] Provoked by the build-up to war, the Non-Aligned Movement (NAM), representing 120 mostly developing countries, initiated a campaign focusing on North-South equity issues in nuclear diplomacy. In the background, the IAEA Department of Safeguards had been working for about a decade toward the establishment of a fundamentally more intrusive verification approach than that which it had applied since the IAEA was created in 1957.

In the months prior to the US invasion of Iraq, IAEA Director General Mohamed ElBaradei had crossed wires with Washington by challenging its rationale for going to war. After Elbaradei encountered friction with the US over Iraq, he injected himself into nuclear diplomacy with Iran in an attempt to avoid conflict escalation. During this period speculation was rife that the US might also invade Iran, a step which ElBaradei warned would be an 'act of madness.'[13] For six years, until ElBaradei was succeeded in 2009 as Director General by a Japanese diplomat, Yukiya Amano, US officials would scold ElBaradei that 'The IAEA is not in the business of diplomacy [but] is a technical agency that has a Board of Governors of which the United States is a member.'[14] This deterioration of US–IAEA relations at the political level was unprecedented. Never were the US and the IAEA so divided over an important verification issue that ElBaradei, correctly, characterised as 'a matter of war and peace.'[15]

In late 2003 the NAM established a Vienna chapter. Iran, facing potential isolation over the IAEA's findings, was the most important NAM member driving this development. Iran crafted a narrative which portrayed itself as a victim of discrimination by the US and other advanced nuclear powers depriving the developing world of its right to peaceful cooperation enshrined in NPT Article IV. ElBaradei's defiance, on the eve of the war, of US allegations that Iraq had resumed trying to make nuclear weapons was followed by Iranian protests that the US and its allies also aimed to attack Iran on baseless grounds that Tehran, likewise, sought atomic arms. Not all NAM states shared Iran's conviction, but Iran's capacity to mobilise developing countries in its favour was a factor that both Western powers and the IAEA Secretariat had to consider in the board of governors and the IAEA General Conference, where policy decisions were taken. It was no coincidence that right after Amano was elected in 2009 by the board at the end of a polarised contest that pitted Amano's Western supporters against developing countries opposing his election, Amano assured developing states that he would prioritise their needs and not overly focus on safeguards and non-proliferation.[16]

During the Iran crisis the IAEA could no longer count on Western and non-Western powers finding common interests that, throughout the Cold War, had smoothed over delicate IAEA verification issues. In previous cases—North Korea, Romania, South Africa, and Iraq—the big powers were on the same page. But during the 2000s Tehran would exploit opportunities to divide the US, the European Union, and Russia, delaying sanctions and giving Iran more time to accumulate nuclear assets and improve its negotiating position with both the IAEA and its member states.[17]

The verification context

In 2003, the IAEA was in the midst of a long-term process of adjusting its safeguards system to be able to detect the kind of undeclared activities which the IAEA would now be challenged to discover in Iran. The MAP was in place in 1997, but Iran had not concluded an AP. The spectacular find at Natanz of a hidden large-scale, under-construction centrifuge enrichment plant, which touched off the Iran crisis, was unveiled by intelligence agencies—not IAEA spadework. In 2002, the IAEA was briefed by member states about this discovery, and the IAEA followed up on that information with Iran.[18]

Until after the Gulf War, the IAEA relied nearly exclusively on material accounting to verify states' declarations of their nuclear activities. In response to post-war discovery of a secret, massive Iraqi nuclear weapons programme, IAEA management soon concluded that something like a paradigm shift in the IAEA's safeguards approach would be necessary.[19] The IAEA began by making changes permitted under its existing legal authority, for example concerning the early reporting of design information. In 1993 it launched a coordinated effort, Programme 93+2, to identify and develop a comprehensive set of measures to strengthen safeguards. Between 1993 and 1997, the secretariat and member states systematically planned and negotiated a sweeping agreement on such measures, including some requiring additional legal authority. In 1997 this became the MAP.[20] As provided for in the foreword to the MAP, the board requested the director general to use the model as the standard for APs for states party to CSAs, and directed that such APs shall contain all of the measures in the model.

For states with CSAs that voluntarily agree to conclude and implement an AP, the protocol gives the IAEA greater access to information and locations in the interest of detecting undeclared activities. Where the IAEA under CSAs had been provided with information related to nuclear facilities and to the flow and inventory of nuclear material, under APs it would also receive data about a broad range of states' nuclear fuel cycle activities.[21]

The AP complements states' existing CSAs in important ways:

- *Correctness vs. completeness:* While INFCIRC/153 permits the IAEA to verify the correctness of a state's inventory declarations (non-diversion of declared nuclear materials) and the completeness of a state's declarations, the IAEA was less attentive to the issue of completeness regarding possible undeclared activities. Inspector access was focused, as a practical matter, mostly on declared facilities at locations identified by the state concerned. The IAEA in theory could carry out 'special inspections' at other locations, but this tool was largely avoided as it was regarded as confrontational.
- *Scope of verification:* Under INFCIRC/153, the earliest stages of nuclear material processing, and the production of low-grade, so-called 'pre-34(c)' nuclear material, were not subject to routine declaration and inspection. Iraq exploited this loophole for its clandestine programme. The MAP was therefore designed to capture states' entire nuclear fuel cycles. In addition, while NPT Article III.2 calls for safeguards as a condition of supply on equipment especially designed for the production of nuclear material, INFCIRC/153 provided the IAEA no mechanism for verifying

compliance with that obligation, nor did it cover R&D programmes not involving nuclear material. The MAP was intended to rectify these limitations as well.

- *Environmental sampling:* IAEA inspections in post-war Iraq for the first time made large-scale use of swipe samples including particle samples exposed to mass spectroscopic analysis, referred to as 'environmental sampling'. CSAs permit the IAEA to carry out environmental sampling anywhere the IAEA has access, that is, during design information verification (DIV) and inspections. The MAP was designed to permit the IAEA broader access for such sampling.
- *Access to locations:* IAEA inspections showed that Iraq had conducted many undeclared activities at locations routinely off-limits to inspectors under a CSA. The AP significantly enlarged the IAEA's access to locations beyond those declared as hosting nuclear activities.

Throughout the 1990s, the IAEA Secretariat argued to the board of governors that, because the above measures required additional authority to be routinely implemented, the IAEA needed a formal protocol that would legally commit states to cooperate and thus obviate concern that, at any time, a state could withdraw its permission.[22]

Iran and IAEA safeguards

Developments before 2003

Before February 2003, when ElBaradei returned from Iran having seen that Iran was constructing a uranium enrichment plant, Iran had never been cited for any infractions of its safeguards agreement during the 29 years it had been in force. Nonetheless, the IAEA during the 1990s had been confronted with information suggesting that Iran was engaged in unreported nuclear activities. That information did not lead to IAEA confirmation that Iran had failed to declare nuclear activities. One former safeguards director later claimed that in early 2002, just before the IAEA was first briefed by member states about allegations that Iran was building an enrichment plant, IAEA personnel 'suspected that Iran had been out of compliance [with its CSA] for about five years.'[23]

In May 1991, the author of this chapter published an account based on information asserting that Iranian nuclear officials had met secretly with Pakistani scientist Abdul Qadeer Khan.[24] Outside the public domain, several states briefed the IAEA on data they obtained that 'indicated possible undeclared nuclear activities in Iran.'[25] In response, the IAEA and Iran agreed to several so-called 'transparency visits' by the IAEA to Iran, including to a few sites identified in media reports as hosting nuclear activities. The IAEA was unable to confirm as a result of these visits that any undeclared activities had taken place in Iran.[26]

Iran's Additional Protocol

Until late 2003, Iran limited its cooperation with the IAEA on the grounds that safeguards in Iran followed from Iran's CSA without an AP.[27] Iran signed an AP in December 2003, but to date Iran has not brought it into force.[28]

When the IAEA began following up on its February 2003 findings, Iran refused to allow the IAEA to take environmental samples at previously undeclared locations which the IAEA believed were part of Iran's enrichment programme. Iran later permitted the sampling, which revealed traces of enriched uranium at one key workshop, and, in August, the IAEA found that this site had been modified, possibly affecting the accuracy of the sampling analysis.[29]

Beginning in June the board of governors had urged Iran to 'promptly and unconditionally' conclude an AP.[30] Iran in October 2003 agreed to sign and then voluntarily implement an AP as part of a deal struck with the EU to avoid a finding by the Board of governors of non-compliance by Iran with its safeguards agreement and a concomitant reporting of Iran to the United Nations Security Council. This, ElBaradei told the board in November, was a major development, since 'the IAEA's ability to reach a conclusion on the nature of Iran's nuclear programme and the correctness and completeness of Iran's declaration of its nuclear activities will very much depend on the Agency being allowed by Iran to implement in full the verification measures provided for in the safeguards agreement and the Additional Protocol.' Iran had signed its AP in December to deflect a report by the Board on Iranian non-compliance to the Security Council and to permit Tehran to 'manage existing political and other pressure on Iran.'[31] Iran told ElBaradei and the EU it 'would accept provisional implementation of the AP and pursue a policy of full transparency as a confidence-building measure.'[32]

Less than a year after Iran signed and began implementing its AP, the Iran–EU accord that was the basis of Iran's voluntary AP commitment 'collapsed,'[33] and in February 2006 Iran formally suspended the provisional implementation of its AP.[34]

Safeguards non-compliance

With hindsight, a few safeguards experts have suggested that, had the IAEA correctly interpreted Iran's extended delay in bringing its AP into force as a sign that Iran would not indefinitely cooperate, the IAEA would have taken greater advantage of what in fact was a small window of opportunity. But the record suggests that between December 2003 and February 2006, Iran cooperated significantly, and that the IAEA, by then benefiting from cooperation from member states providing intelligence findings, made significant discoveries. This was possible because the IAEA obtained documents, and carried out interviews, inspections, and environmental sampling in Iran, in particular at several undeclared locations where the IAEA suspected that Iran may have been engaged in clandestine nuclear activities. During AP complementary access at several sites in early 2004,[35] including military locations, the IAEA found reprocessing equipment.[36] Between June and September 2004, the IAEA carried out complementary access at six locations related to: centrifuge enrichment and testing; laser development; uranium conversion, purification, and casting; plutonium separation; uranium mining and ore processing; and other theretofore undisclosed R&D activities.[37] During 2004 and 2005, the IAEA obtained and discussed with Iran its AP declarations, which contained information on projects for zirconium production and fuel fabrication.[38] In parallel, the IAEA made other findings through cooperation with member states that provided data on Iranian procurement for undeclared activities, including information that suggested that Iran might have worked on the development of nuclear weapons.

AP implementation contributed to these findings. But the most startling breakthroughs did not arise from complementary access under the AP *per se* but from Iran's declarations that it had previously deceived the IAEA about uranium dioxide (UO_2), uranium tetrafluoride (UF_4) and uranium hexafluoride (UF_6) conversion experiments; centrifuge testing using UF_6; plans to enrich uranium at the Natanz site; procurement of centrifuge design information; laser enrichment; and work on the more advanced P2 centrifuge.[39]

During 2005, as the IAEA's knowledge about undeclared Iranian nuclear activities increased, diplomacy began breaking down. In September 2005, the board decided that Iran's many breaches of its obligations under its CSA constituted non-compliance, and, in February 2006, requested ElBaradei to report Iran's non-compliance to the UN Security Council.

Iran engaged NAM states to oppose the reporting. While they could not prevent board resolutions from being adopted,[40] NAM countries obstructed consensus adoption of the resolutions in September 2005 and February 2006, an outcome which Iran and some NAM states argued rendered the board's findings less legitimate.[41] Iran contended that because the board did not promptly find it in non-compliance in 2003, and because the country had resolved numerous non-reporting issues with the IAEA between 2003 and 2006, the three-year delay weakened the case for the board's 2006 reporting of the matter to the UN Security Council.[42] Absence of clarity in both the NPT and the IAEA Statute about what constitutes non-compliance delayed decision-making.[43] Iran argued, on the basis of Article XII.C of the IAEA Statute, that non-compliance must be determined by IAEA inspectors, and it pointed out that the IAEA's reports did not use the term 'non-compliance.' But Iran's view was not shared by the IAEA or other states.[44] A separate dispute arose about whether reporting of non-compliance to the UN Security Council by the board of governors was mandatory as suggested by Article XII. C of the Statute—as the United States argued—or instead was discretionary as suggested by paragraph 19 of INFCIRC/153.[45] A prompt non-compliance finding in

2003 might have bolstered the IAEA's credibility and blunted Iran's later claim that it was the victim of a conspiracy of big powers. But it might also have foreclosed the opportunity for the IAEA to discover much of what it subsequently learned about the extent of Iran's hidden nuclear programme.

PMD: beyond the Additional Protocol

Since 2006, the IAEA has collected data suggesting that Iran had begun to work on the development of nuclear arms in the mid-1980s and continued at least until 2003. As described by the secretariat, this information called into question the completeness of Iran's declarations.

As in the case of the non-compliance finding, politics influenced how IAEA data concerning 'possible military dimensions' (PMD) of Iran's nuclear programme would be handled. Here too, ElBaradei avoided taking actions that, in his view, would escalate the crisis.

Until succeeded by Amano, ElBaradei resisted urgings of some IAEA personnel and Western powers that he formally report on the contents of the PMD dossier to the board.[46] Amano personally reversed this policy and in November 2011 provided governors with the IAEA's summary analysis of that information.[47]

As in the matter of delayed non-compliance, some participants have asserted that the IAEA's decision making on PMD allegations rendered conflict resolution more difficult. Russia warned throughout 2011 that Iranian leaders would never confess that Iran worked on nuclear weapons because that would seriously compromise the Iranian political regime. Should the IAEA formally air the PMD allegations, Moscow argued, Iran could never admit that they were true. Subsequent assertions by Iran that nuclear weapons are contrary to Islamic law made it still less likely that Iran would answer to the allegations.

During consideration in the 1990s about what should be included by states in their AP declarations, the IAEA Secretariat had proposed including weaponisation activities,[48] but the final text contained no reference to either weaponisation or to non-nuclear or dual-use equipment unrelated to production of nuclear material.[49] In reporting Iran to the Security Council in February 2006, members of the board of governors explicitly requested that the IAEA pursue PMD allegations, spelling out that Iran must 'implement transparency measures . . . which *extend beyond the formal requirements* of the Safeguards Agreement and Additional Protocol, and include such access to individuals, documentation relating to procurement, dual use equipment, certain military-owned workshops and research and development as the Agency may request in support of its ongoing investigations.'[50] On 31 July 2006, the Security Council required Iran to provide this access.[51]

The above-cited language was drawn directly from the most contemporary IAEA report to the board on Iran's safeguards implementation at that time, and represented, in the view of one former Western diplomat, ElBaradei's 'cautious understanding of what constitutes the IAEA's safeguards authority.' But it would be wrong, he said, to conclude from the text of this resolution 'that the IAEA could not ask questions and expect answers from states about whether they have done work relevant to making nuclear explosives.' Because weaponisation is not explicitly mentioned in the MAP as a domain for IAEA pursuit, and is not a component of the nuclear fuel cycle, the relationship between nuclear weapons-making activities outside the fuel cycle and the AP 'has long been a grey area.' It is not the only one. During the 1990s the United States proposed including in the MAP an obligation for states to report tritium production. This was debated and not included in the final text, but in the opinion of the former Western diplomat 'it would be absurd to conclude from this that the IAEA could not pursue allegations that a state may be making tritium.'[52]

Iran claimed that it is under no legal obligation to address the PMD allegations.[53] Nonetheless, Iran and the IAEA concluded two successive agreements aimed at resolving them: a so-called 'Work Plan,' in August 2007 and a Framework for Cooperation, in November 2013.[54] Neither has been fully implemented, although cooperation under the latter is ongoing and is the basis for understandings between Iran, the powers, and the IAEA concerning resolution of PMD issues under the JCPOA.[55]

State-level safeguards and Iran

Since the 1990s, the IAEA has adopted the view that safeguards under CSAs should be based on an evaluation of a state's nuclear programme as a whole, as opposed to being focused on individual nuclear facilities.

In evolving its approach to the planning, implementation and evaluation of strengthened safeguards, the IAEA has used the terms 'information-driven safeguards,' 'integrated safeguards,' and 'state-level' safeguards to describe certain aspects. But these terms are not interchangeable:

- *Information-driven safeguards* was a term used by the IAEA to describe the use of all available data sources to make safeguards judgments: state-supplied information, including data from nuclear material accountancy and declarations under CSAs and APs; results from IAEA verification activities, including inspections, DIV, and complementary access; and other safeguards-relevant information from open sources and third parties.[56]
- *Integrated safeguards* was a term coined by the IAEA in 1998 to describe the optimisation of safeguards implementation in states with CSAs and APs, informed

by the desire to eliminate redundancies and reduce costs.[57] If the IAEA had no indications that a state had diverted any nuclear material from *declared* activities, and there were no indications of any *undeclared* nuclear material or activities, it could conclude that all nuclear material remained in peaceful activities–a judgment described as the 'broader conclusion'. On that basis, the IAEA would have sufficient assurance to be able to reduce the state's routine safeguards burden.

- *State-level approach* (SLA) is defined as safeguards 'developed for a specific state, encompassing all nuclear material, nuclear installations and nuclear fuel cycle related activities in that state [including] safeguards measures . . . [to] enable the IAEA to draw and maintain a conclusion of the absence of undeclared nuclear material and activities in that state'.[58]
- *State-level concept* (SLC) is the term used since 2004 to describe the process of the planning, implementation and evaluation of safeguards looking at the state as a whole. It was introduced 'to describe safeguards implementation that is based on State-level approaches developed using safeguards objectives common to all States with CSAs and taking State-specific factors into account [and] . . . implemented for States with integrated safeguards'. Since 2004 IAEA officials have expressed the aim to apply state-level safeguards in all states subject to safeguards.[59] In 2014 the IAEA informed member states it would focus on implementation of state-level safeguards in countries with both CSAs and APs.

In recent years member states have questioned the IAEA about what the SLC means and implies, especially concerning the IAEA's legal mandate to implement safeguards, issues of equity and discrimination, and the IAEA's objectivity in forming safeguards judgments. These issues came to a head in 2012 when Russia and some others voiced objections and requested clarification from the IAEA.[60]

Many of these issues had previously been discussed during negotiation of the MAP.[61] Then, however, states widely shared the view that IAEA safeguards should be strengthened. This was so for specific reasons, including: the recent experience of the IAEA in Iraq, in North Korea, and South Africa; the leadership of influential board members and the secretariat; and the inability of a defeated Iraq to influence board decision making.[62] By contrast, current safeguards diplomacy is often acrimonious, including objections that IAEA non-proliferation efforts detract from states' access to peaceful nuclear development.[63]

During the 1990s, the IAEA Secretariat had to involve its member states in the conceptualisation process for strengthening safeguards because the secretariat sought additional legal authority in the MAP. Since the 2000s, however, the secretariat has argued that no additional legal authority from the states was required for the development of state-level safeguards. This may have encouraged safeguards personnel not to communicate their thinking to states.[64] By 2012 a number of member states felt that the IAEA had become unwilling to share information with them regarding how the agency wanted to move forward with safeguards development.

Outside the politicised IAEA boardroom, the secretariat continues to move forward with the development and implementation of safeguards at the state level. In practice, for a country subject to state-level safeguards, the IAEA derives an annual implementation plan in tandem with an annually updated state evaluation report (SER) based on all information available to it. Part C of SERs contains an analysis of possible proliferation scenarios examining all plausible acquisition paths for that state to obtain a nuclear explosive device, in consideration of the state's existing facilities, knowledge and expertise, past R&D activities, capacity to import technology and knowhow, and the state's available resources.[65] The IAEA then develops and prioritises state-specific technical safeguards objectives, also informed by state-specific factors, which include the history of the state's cooperation with the IAEA on safeguards implementation and the state's legal framework. Safeguards measures for the state are then identified to achieve the safeguards goals. The selection of measures in each case depends on the authority the IAEA has to carry out safeguards in the state, depending on whether a state has a CSA only or, also, an AP.

The term SLC was formally introduced one year after Iran's record of deception was revealed. Iran was by no means a prime driver behind the conceptualisation of state-level safeguards, but the SLC's aspirations closely matched the IAEA's goals for its expanding Iran investigation. As ElBaradei told the IAEA Board of Governors in February 2006, because of the 'existence in Iran of activities undeclared to the agency for 20 years,' the IAEA must 'fully reconstruct the history of Iran's nuclear programme.'[66] To do that, the IAEA drew on important tools used for state-level safeguards, including trade data, satellite imagery, and third-party information to develop a comprehensive and routinely updated country profile; acquisition path analysis for prioritising and pursuing investigations and identifying appropriate safeguards measures; and state-specific factors.

The IAEA's approach to Iran has departed in some ways from its blueprint for state-level safeguards. Instead of compiling an SER, the agency has regularly reported developments to the IAEA Board of Governors. While implementation of SLAs has become working-level routine for many states, the high visibility and priority of the Iran probe meant that it would be managed at the most senior level at the agency by the Director General and the Head of the Department of Safeguards.

As the IAEA uncovered an increasingly complex nuclear programme in Iran, this work accounted for a growing share of the IAEA's safeguards resources, funded exclusively by member states' voluntary contributions. By 2012, the IAEA was spending annually over 12-million Euros on verification in Iran—more than for any other state except Japan.[67]

Verification under the JCPOA

On 14 July 2015, Iran and its six negotiating parties concluded the JCPOA intended to lead to the resolution of all outstanding questions about Iran's nuclear programme. This agreement was the result of a twelve-year diplomatic process designed to trade off Iranian commitments to nuclear transparency and restraint for commitments by the other six parties to lift economic sanctions imposed on Iran. Before conclusion of the JCPOA, in November 2013 Iran and the six agreed to the Joint Plan of Action (JPA), a preliminary agreement aimed to point the way toward the final settlement.

The point of departure for negotiation of terms of verification was Iran's CSA. For numerous reasons, parties negotiating with Iran wanted the JCPOA to contain provisions that exceeded Iran's CSA and its AP.

When the agency began to make discoveries in 2003, it informed the IAEA Board of Governors that without more authority than expressed formally in Iran's CSA and AP, it could not assure that Iran's nuclear programme was wholly peaceful. In September 2005, for example, it said: 'Given Iran's past concealment efforts over many years, [needed additional verification] measures should extend beyond the formal requirements of the Safeguards Agreement and Additional Protocol and include access to individuals, documentation related to procurement, dual use equipment, certain military owned workshops and research and development locations. Without such transparency measures, the Agency's ability to reconstruct, in particular, the chronology of enrichment research and development, which is essential for the Agency to verify the correctness and completeness of the statements made by Iran, will be restricted.'[68]

JCPOA negotiators envisaged the final result as a package that consisted of the JCPOA and an IAEA-Iran 'Roadmap' for 'clarification of past and present outstanding issues,' both of which were concluded and announced on 14 July. Together they would contain detailed arrangements concerning the IAEA's access to Iran. States negotiating with Iran sought for the IAEA as much access as possible because they were not confident that Iran would fully cooperate with the agency. Contrary to the official record in statements by governors and the IAEA Secretariat,[69] Iran has claimed, most recently in December 2014, that the IAEA is not authorised to verify both correctness and completeness of Iran's nuclear declarations.[70]

To facilitate the IAEA reaching the 'broader conclusion' for Iran, the JCPOA included specific provisions concerning weaponisation that exceeded Iran's CSA and

AP. The aim of reaching the broader conclusion for Iran had been set forth in the first sentence of the JPA: ‘The goal for these negotiations is to reach a mutually-agreed long-term comprehensive solution that would ensure Iran’s nuclear programme [is] exclusively peaceful.’ This is consistent with the aim of IAEA safeguards development since the 1990s to provide assurances that states are not engaged in undeclared activities and to reach broader conclusions for states that are implementing the AP. It is also consistent with the safeguards goal for Iran expressed routinely by the secretariat’s reports to the board since 2003, namely, ‘that all nuclear activities are dedicated to peaceful uses.’

But while states negotiating with Iran aimed to include provisions beyond Iran’s CSA and AP, the result fell far short of what some observers had claimed was necessary. A former IAEA safeguards director argued before the agreement was concluded that ‘Iran must provide the IAEA with unconditional and unrestricted access to any and all areas, facilities, equipment, records, people [and] materials . . . which are deemed necessary by the IAEA to fulfil its requirements under [Iran’s] safeguards agreement and to verify Iran’s declarations.’[71] But Iran successfully brushed off demands that it agree to such ‘anytime, anywhere’ inspections and that it abandon its enrichment programme.[72] Others had proposed that final sanctions-lifting be conditional on a ‘broader conclusion’ by the IAEA;[73] this also was not agreed to by Iran. JCPOA negotiators from Western states later said that they had insufficient collective leverage to compel Iran to provide greater access to the IAEA regarding persons, locations, and information.[74]

The final result of negotiations for a comprehensive agreement nonetheless encompassed numerous provisions which went beyond Iran’s CSA. The most important of these include:

- *Greater IAEA surveillance on Iran’s enrichment programme:* For terms between 10 and 25 years for specific activities, Iran’s enrichment programme will be subject to additional oversight. This will include IAEA verification of limits on production of enriched uranium and other enrichment-related activities, annual assessment of Iran’s centrifuge R&D programme, and more extensive safeguards on uranium processing from uranium concentrate through to production of uranium hexafluoride. The agreement also provides for the IAEA’s use of up-to-date technology for uranium enrichment safeguards.
- *Provisions concerning activities at the Arak site:* The IAEA will monitor a foreseen modification of the IR-40 research reactor, review design information for a replacement reactor, and oversee heavy water-related activities.
- *Implementation of the Additional Protocol:* Beginning in 2016 Iran will indefinitely implement its AP, toward the aim that the IAEA conclude that all nuclear activities

in Iran are for peaceful use. Should Iran not comply with requests for complementary access, parties will resort to an adjudication process with the goal of providing the IAEA access it requires.

- *Procurement:* A working group of state parties to the JCPOA will review and decide on all procurement transactions for Iran's nuclear programme, for items listed on the Nuclear Suppliers Group nuclear use and nuclear dual use lists. Iran will provide the IAEA access to all locations where imported nuclear use-listed goods will be used.
- *PMD and weaponisation activities:* For the purposes of safeguards under Iran's SLA, the IAEA needs a baseline understanding of Iran's capability to make nuclear weapons, provided by access to locations, personnel, and data in Iran. The JCPOA calls on the IAEA and Iran to resolve PMD allegations such that the IAEA has sufficient information; it will permit the IAEA to design safeguards goals and implementation plans. Separately, the JCPOA commits Iran not to engage in specific weaponisation activities.

In 2005, the IAEA Secretariat had concluded that the MAP has certain limitations. These include an absence of deadlines for states to respond to IAEA requests for information or clarification; the lack of obligations for states to report on domestic-sourced nuclear equipment; the absence of provisions concerning IAEA right of access to persons in a state; and strict limitations on the scope of IAEA activities that may be undertaken in a state related to complementary access. These limitations were the consequence of the negotiation of the MAP between 1995 and 1997.[75] For a state which has routinely and fully cooperated with the IAEA in implementing safeguards, these shortfalls may matter little in practice. But given Iran's record of selective cooperation with the IAEA, they might factor significantly. Some points were addressed by the JCPOA—such as the IAEA's access, adjudication deadlines, and verification of limits on uranium enrichment activities by Iran. Some issues may be addressed by Iran and the IAEA in confidential detailed access provisions.

The November 2013 JPA had called for a subsequent JCPOA to include 'agreed transparency measures and enhanced monitoring' going beyond the AP. During the ensuing negotiation, the parties and the IAEA negotiated understandings about what additional information Iran must provide, and what access to information, persons, and locations in Iran would be necessary to resolve 'past and present outstanding issues', including PMD allegations. While previously agreed 'transparency measures' were voluntary, the 'Roadmap' may include confidential and binding understandings about the IAEA's specific authority to resolve 'past and present outstanding issues', including PMD.[76]

The JCPOA aspires to reach the 'broader conclusion' for Iran in eight years or less. Informal estimates of how much time the IAEA would need vary greatly. In 2010 a former IAEA safeguards director said that, because the IAEA had learned much about Iran's nuclear programme since 2003, it could, with full cooperation from Iran, reach a broader conclusion in about three years.[77] Five years later, and on eve of the JCPOA, a former director of safeguards asserted that the broader conclusion might take 'many years' and advised that 'the duration of [a comprehensive agreement] up to 20 years is reasonable in light of the two decades of non-compliance with [Iran's] safeguards obligations and non-cooperation with the IAEA.'[78]

The challenge for nuclear verification under the JCPOA will be considerable for several reasons: the Iranian regime's track record of deliberate concealment of nuclear activities from the IAEA; the lack of trust between Iran and the other parties to the JCPOA; the complexity of Iran's nuclear programme and especially its nuclear fuel cycle; and the persistence of allegations that Iran has secretly worked on the development of nuclear weapons. Iran, unlike post-Gulf War Iraq, is a fully sovereign state and it can be expected to take all measures it deems appropriate to further its national interests during implementation of the JCPOA.

Iran and the future of nuclear verification

What can we conclude after a decade of intensified IAEA verification in Iran?

- Until third parties provided the IAEA with information revealing the extent of Iran's uranium enrichment programme, the agency had not identified any undeclared nuclear activities in the country. The agency in 2002 acted on this third-party information, and in 2003 confirmed the existence of Iran's enrichment project at Natanz. Before 2002, the IAEA may have been hindered in making findings by the absence of an AP in Iran and by the absence of well-founded third-party information, including from member states, and perhaps by certain provisions in Iran's CSA including those concerning inspector designation and access.
- Since 2005, the IAEA has had comparatively little difficulty in re-establishing and thereafter routinely assuring that all of Iran's declared nuclear materials and activities are accounted for.
- Iran's voluntary implementation of its AP in 2004 and 2005 gave the IAEA access to information that allowed it to discover hidden aspects of Iran's nuclear programme.
- Iran's withdrawal of consent to implement its AP in 2005 validated the IAEA's longstanding concern that the elements of the MAP should be implemented on the basis of legally binding instruments.

- The most significant revelations about Iran's nuclear activities in 2003 and 2004 resulted not from complementary access activities through an AP but from Iran's declarations. This underlines that, independent of the IAEA's legal authority, effective verification depends on the cooperation of the state subject to safeguards.
- The decision of the IAEA Board of Governors, encouraged by the secretariat, not to cite Iran for non-compliance in 2003 may have weakened the IAEA's credibility; it exposed the board and the secretariat to charges by Iran that the 2006 finding was arbitrary. But a prompt non-compliance finding might have prevented the IAEA from making important discoveries.
- In reporting Iran to the UN Security Council, the board pronounced that certain IAEA verification activities in Iran formally exceeded the scope of Iran's CSA and AP. This position may have reflected the then-Director General's conservative view of the IAEA's safeguards mandate, but it is not a consensus understanding of the IAEA's safeguards authority under the MAP and CSAs.
- Expressing increased concern since 2003, the IAEA routinely informed the board that it could not conclude that all nuclear material and activities in Iran are dedicated to peaceful use unless Iran implements its AP and provides access beyond its AP that is based so far on voluntary measures. The IAEA thereby encouraged negotiators to include in the JCPOA specific provisions going beyond Iran's AP.
- In light of Iran's perceived proliferation risk, beginning in 2003 and supported by the board, the IAEA has implemented state-level safeguards in Iran to an unprecedented degree of intensity and scope, given the comparatively modest size of Iran's nuclear programme. The IAEA's information collection, analysis, and verification activities account today for largest share of the effort and expense required to implement a state-level approach in a country with just one power reactor but where total safeguards costs may approach the level of costs in Japan, the world's most safeguarded country.[79]

During the last quarter century, the IAEA has been reorienting safeguards away from routine accounting of declared materials and activities using universal implementation criteria that are explicitly non-discriminatory, and toward a more risk-based approach where implementation is based on unique conditions prevailing in each state subject to safeguards. But states want assurance that adjustments made by the IAEA will result in safeguards judgments that are objective and technically based, and that are not subject to political or other subjective considerations.

To be sure, the political environment surrounding safeguards decision making by the IAEA is today more contentious than at any previous time. During the 1990s, decisions taken by both the IAEA Secretariat and member states in response to violations by Iraq and North Korea prompted little or no dissent in IAEA policy-making bodies. A decade later, key decisions taken on Iran proved highly controversial. These included the timing of a finding that Iran was in non-compliance with its safeguards obligations, and a decision of the Director General to report to the IAEA Board of Governors allegations that Iran had worked on nuclear weapons.

While for Western states the Iran crisis was about Iran's non-compliance with its obligations, Iran, joined by developing and non-aligned countries, brought forth a narrative which framed the crisis as being instead about the IAEA's objectivity, competence, and authority, and about states' 'nuclear rights'. In view of Iran's deception, most member states acquiesced to the IAEA Secretariat's decisions and findings on Iran. But the themes Iran raised in its defence increasingly resonated among some member states in discussion in the board and the IAEA General Conference about the agency's development of the SLC, especially since 2012.

Given this background, during implementation of the JCPOA the IAEA may be challenged to demonstrate that it is implementing safeguards in Iran according to the letter of its legal authority and obligations, and that it will not be unduly swayed by powerful member states that have concluded an informal political arrangement with Iran.

What the IAEA's Iran investigation will mean for the future of nuclear verification will depend more than anything else upon whether the JCPOA succeeds in reducing the threat posed by Iran's nuclear programme. If JCPOA parties and the IAEA implement the agreement smoothly, states' confidence in the SLC will be enhanced. If not, debate over the future of safeguards may intensify. A critical actor will be Russia, which contributed to the success of the JCPOA negotiation and has also raised critical questions in IAEA decision-making bodies over the future of the SLC.

During interventions in the IAEA boardroom, governments that negotiated the JCPOA with Iran underlined that intensified verification in Iran followed from IAEA Board of Governors and UN Security Council resolutions. They did this in part to get support from other states for resolutions and sanctions, and because they were fully aware of many states' lack of enthusiasm for additional safeguards activities, which beginning in 2012, was expressed in debate about the SLC in the board and the IAEA General Conference. Accordingly, most states currently understand that the IAEA's implementation of state-level safeguards does not imply that their nuclear activities will be subject to open-ended and wide-ranging IAEA investigations such as that carried out in Iran.[80]

Many Western governments, including parties to the JCPOA, are on record as asserting that, while the decision to conclude an AP is voluntary, the AP is nonetheless a component of the 'current IAEA verification standard.'[81] The JCPOA will in 2016 remove Iran from the very short list of states with large-scale and advanced nuclear activities that are not implementing an AP. But the JCPOA does not require Iran's AP to enter into force, providing Iran a potential legal avenue to suspend AP implementation once all sanctions against Iran are lifted. Iran's future actions may therefore have significant bearing on efforts by the IAEA to universalise the MAP.

Western JCPOA parties also advocate that some unique provisions in the agreement, apart from Iran's CSA and AP, should in the future be incorporated into an 'enhanced verification standard.'[82] A few of these elements might be accepted by most states with little difficulty, such as those permitting the IAEA to upgrade the technology standard of safeguards equipment. Western states may encourage the IAEA to move forward in Iran toward the establishment of a wide area environmental sampling program that could serve as a general model. Other measures in the JCPOA may be less willingly adopted elsewhere.

The most important aim of states negotiating the JCPOA with Iran was to assure that Iran's break-out time—the time Iran would need to produce enough weapons-grade uranium for one nuclear weapon—would be at least a year. Many of the safeguards provisions in the JCPOA that exceed the terms of Iran's CSA and AP, such as verified limits on enrichment and greater surveillance over centrifuge production, were included to support this outcome.[83] These provisions also track with the IAEA's state-level acquisition path analysis for Iran. An effort to extend these provisions to other states might be resisted by governments and industries in states with uranium enrichment programmes and which, following from their SLAs, pose less proliferation risk.

The JCPOA's verification costs must be met for a decade or more. Because the expense of implementing additional safeguards—including in Iran—must be supported by states' voluntary contributions, cost considerations may discourage adoption by other states of many or most JCPOA provisions exceeding CSAs and APs.

The Iran crisis focused discussion upon the significance of R&D activities related to making nuclear explosives, and proposals have been made to urge non-nuclear-weapon states to take on Iran's obligation not to engage in specific weaponisation-related activities.[84] Some, perhaps many, states may be willing to make this commitment. But should it be suggested that any obligation upon states not to weaponise be subject to special verification, difficulties would arise. States may not agree to grant the IAEA explicit authority to investigate weaponisation allegations based on third-party information. Indeed, the IAEA Secretariat might argue that it needs no such specific authority, since for a state with a CSA, allegations of weaponisation would question the completeness of that state's declaration. More generally, the IAEA may caution that a push to generalise specific provisions in the JCPOA for other states would be counterproductive to the IAEA's ongoing effort to universalise the MAP.

With many or most governments unwilling to assume more IAEA safeguards obligations, and no ironclad consensus among states about the IAEA's safeguards mandate in certain areas, some observers propose that the UN Security Council instead be tasked to verify that states are not preparing to make nuclear explosives.[85] The council might be the logical locus for such an authority since its permanent members are nuclear-armed and because nuclear weapons-making would constitute a threat to peace under the United Nations Charter. But it is not obvious that states not prepared to grant the IAEA greater authority would endow an unreformed UN Security Council run by five nuclear weapons powers with the right to police R&D activities in 186 states that have pledged to foreswear atomic arms.

Going beyond concerns about whether Iran was engaged in nuclear explosives-making, the Iran crisis increased worry that other states may hedge and develop capabilities that could give them a future nuclear weapons option. Debate over Iran exposed a lack of consensus about what activities are consistent with the 'use of nuclear energy for peaceful purposes' under NPT Article IV.[86] Perhaps in the future NPT parties might address the threat of 'safeguarded proliferation' in a multilateral accord that more precisely defines the scope of peaceful activities. But that would be decided in a realm far from the confines of IAEA safeguards.

States may not favour assuming additional and unique provisions of the JCPOA because they believe these were justified solely by Iran's record of concealment. Should this view prevail, Iran will be seen by many or most IAEA member states as an exception rather than a harbinger of greater future proliferation threats warranting additional obligations. Twenty years ago, IAEA member states created the MAP as a voluntary obligation; today however many states view it as an essential and standard safeguards instrument. Unique provisions in the JCPOA might in future become generalised, but likewise only on the basis of voluntarily commitments.

The views and opinions expressed are the author's own, as are any inaccuracies in fact or interpretation.

Endnotes

1 'Implementation of the NPT Safeguards in the Islamic Republic of Iran,' GOV/2003/40, Report by the Director General, International Atomic Energy Agency, June 2003. Available at: www.iaea.org/sites/default/files/gov2003-40.pdf

2 The IAEA carried out a comprehensive investigation of Iraq's nuclear program after that country's defeat and occupation in 1991 by a coalition of states led by the United States.

3 The IAEA began using the terms 'State Level Approach' and 'State Level Concept' during this period. See: James W. Tape, 'The State-Level Approach: Moving Beyond Integrated Safeguards', LA-UR-08-6114, Los Alamos National Laboratory, October 2008. Available at: www.inmm.org/AM/Template.cfm?Section=Evolving_the_IAEA_State_Level_Concept&Template=/CM/ContentDisplay.cfm&ContentID=2966

4 See: Joint Comprehensive Plan of Action Preamble and General Provisions, p.xi. Available at: www.eeas.europa.eu/statements-eeas/docs/iran_agreement/iran_joint-comprehensive-plan-of-action_en.pdf. According to Western JCPOA negotiators and safeguards officials, this language was introduced by Russia.

5 Private communications from several senior officials representing the United States and European state parties to the JCPOA, July, 2014 and September, 2015.

6 This safeguards agreement can be found in IAEA INFCIRC/214, available at: www.iaea.org/sites/default/files/publications/documents/infcircs/1974/infcirc214.pdf

7 Private communications from former United States government and former IAEA personnel, September 2014. In 2007, the IAEA informed the Board that, in addition to Iran's activities related to gas centrifuges, by the mid-1970s Iran had contracted with foreign entities to obtain laser enrichment-related assistance. 'Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions 1737 (2006) and 1747 (2007) in the Islamic Republic of Iran', GOV/2007/58, International Atomic Energy Agency, November 2007. Available at: www.iaea.org/sites/default/files/gov2007-58.pdf

8 'The Structure and Content of Agreements Between the Agency and States Required in Connection With the Treaty on the Non-Proliferation of Nuclear Weapons', INFCIRC/153, International Atomic Energy Agency, June 1972. Iran's safeguards agreement can be found in IAEA INFCIRC/214. Available at: www.iaea.org/Publications/Documents/Infcircs/Others/infcirc153.pdf

9 INFCIRC/214, Article 1.

10 'Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran', GOV/2003/69, International Atomic Energy Agency, September 2003. Available at: www.iaea.org/sites/default/files/gov2003-69.pdf

11 Since June 2003 with few exceptions these reports have been compiled by the IAEA Secretariat every three months and routinely provided to the board as documents classified for restricted distribution. These reports have been declassified by the IAEA and are available on the IAEA website at: www.iaea.org/newscenter/focus/iran/iaea-and-iran-iaea-reports

12 The term 'war of non-proliferation' is used by Campbell Craig and Jan Ruzicka in 'The Nonproliferation Complex,' *Ethics & International Affairs,* Vol. 27, no. 3, 2013. pp. 329–348.

13 Mohamed ElBaradei, *The Age of Deception: Nuclear Diplomacy in Treacherous Times*, London: Bloomsbury, 2011. p. 255. Referring apparently to American neo-conservatives, ElBaradei wrote: 'Everybody wanted to know whom I meant by the 'new crazies' who say "let's go and bomb Iran." I let them draw their own conclusions.'

14 Sue Pleming, 'Rice swipes at IAEA, urges bold action on Iran', *Reuters*, 19 September 2007. Available at: www.reuters.com/article/2007/09/19/us-iran-usa-rice-idUSN1822732020070919. The citation is from US Secretary of State Condoleezza Rice.

15 Responding to the question whether it was a coincidence that Iran's violations were revealed 'just as the US was building up for the Iraq war,' ElBaradei said: 'The Iraqi war had an impact . . . to make everybody understand that weapons of mass destruction could mean the difference between war and peace and in that sense it makes any move to be undeclared very, very difficult, or, or to have — countries have to weigh very carefully whether to, to go for an undeclared programme.' (See the transcript of an interview with Mohamed ElBaradei on PBS Newshour, available at: www.pbs.org/newshour/bb/international-jan-june04-elbaradei_3-18/). According to a former IAEA participant in discussions of the IAEA's response to US allegations against Iran in 2003, ElBaradei 'wanted to make sure the IAEA would not take any decisions which would lead to a war.' According to a former US official at the time, the US position was that 'A decision about going to war wasn't [ElBaradei's] call to make.' Private communications, February 2015 and May 2009).

16 Julian Borger, 'Nuclear watchdog chief accused of pro-western bias over Iran', The Guardian, 22 March 2012. Available at: www.theguardian.com/world/2012/mar/22/nuclear-watchdog-iran-iaea. See also Mark Hibbs, 'Ten Lessons from September's IAEA Diplomacy', Carnegie Endowment for International Peace, October 2010. Available at: carnegieendowment.org/publications/?fa=41682&solr_jump=true&solr_hilite=Syria&reloadFlag=1

17 Seyed Hossein Mousavian, *The Iranian Nuclear Crisis*, Washington, D.C.: Carnegie Endowment for International Peace, 2012. pp. 80–96. Mousavian, spokesman for Iran's nuclear negotiating team between 2003 until 2005, described how some Iranian strategists 'maintained that, by widening the rift between Washington and Brussels, diplomatic activism with Europe could also increase the relative power of the Eastern bloc and lower the political cost of its support for Iran.' Mousavian also said Iran's negotiators beginning in 2005 and under President Mahmoud Ahmadinejad embraced a strategy of leveraging Iran's relationship with Moscow to try to set back Western powers' efforts to sanction Iran.

18 Private communications from former IAEA safeguards officials, June and September 2013.

19 During internal deliberations, members of the board of governors committee to prepare and negotiate the text of the Additional Protocol referred to this as a new 'safeguards culture' based not on trust but on rigorous investigation. See Michael D. Rosenthal, Lisa L. Saum-Manning, Frank Houck, 'Review of the Negotiation of the Model Protocol Additional to the Agreement(s) Between State(s) and the IAEA for the Application of Safeguards', Vol. II, Brookhaven National Laboratory, January, 2010. p. 10.

20 'Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards', INFCIRC/540(corrected), International Atomic Energy Agency, September 1997. Available at: www.iaea.org/sites/default/files/infcirc540c.pdf

21 Michael D. Rosenthal, Lisa L. Saum-Manning, Frank Houck (2010). p. ii.

22 'Strengthening the Effectiveness and Improving the Efficiency of Agency Safeguards', GC(39)/RES/17, General Conference, International Atomic Energy Agency, August 1995. p. 5.

23 Private communication, former IAEA official, July 2012.

24 Mark Hibbs, 'Bonn Will Decline Tehran Bid to Resuscitate Bushehr Project,' *Nucleonics Week*, May, 1991. p. 17.

25 Nima Gerami and Pierre Goldschmidt, 'The International Atomic Energy Agency's Decision to Find Iran in Non-Compliance, 2002–2006', Center for the Study of Weapons of Mass Destruction, National Defence University Press, December 2012. p. 1. Available at: wmdcenter.dodlive.mil/files/2013/01/WMD-Case-Study-6-December-2012.pdf

26 According to one participant in 'transparency visits,' these were unproductive because they were too public and conducted at the executive level, without experienced inspectors who could have made discoveries. Private communication, June 2014. Member states also shared with the IAEA information that Iran had imported, but had not declared, uranium hexafluoride (UF6)—the feedstock for gas centrifuge uranium enrichment—from China. The IAEA did not pursue this because it had no actionable information about where the uranium was located in Iran. During the 1990s the IAEA unsuccessfully attempted to secure information from China considering this transaction. After Iran's violations were exposed in 2003, China confirmed to the IAEA that the UF6 had been exported to Iran in 1991.

27 'Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran', GOV/2003/63, IAEA Board of Governors, International Atomic Energy Agency, August 2003. Available at: www.iaea.org/Publications/Documents/Board/2003/gov2003-63.pdf

28 'Iran Signs Additional Protocol on Nuclear Safeguards', IAEA News Centre, International Atomic Energy Agency, December 2003. Available at: www.iaea.org/newscenter/news/iran-signs-additional-protocol-nuclear-safeguards. In accordance with Article 17 of Iran's AP, the AP will enter into force on the date on which the Agency receives from Iran written notification that Iran's statutory and/or constitutional requirements for entry into force have been met.

29 Nima Gerami and Pierre Goldschmidt (2012). p. 5.

30 'Statement by the Board, 19 June 2003 (Issued by the Chairwoman)', IAEA News Centre, International Atomic Energy Agency, June 2003.

31 Mousavian (2012). p. 98.

32 *Ibid*. p. 99.

33 Nima Gerami and Pierre Goldschmidt (2012). p. 8.

34 'Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran', GOV/2004/11, IAEA Board of Governors, International Atomic Energy Agency, March 2004.

35 Under an AP, the IAEA may carry out 'complementary access' to assure the absence of undeclared nuclear material and activities, to resolve a question or an inconsistency relating to correctness and completeness of the information provided by a state.

36 See: GOV/2006/14

37 See: GOV/2004/60

38 See: GOV/2004/83

39 See: GOV/2003/75, GOV/2004/11, and GOV/2004/32

40 Mousavian reported that, on February 4, 2006, despite votes against by Cuba, Syria, and Venezuela, and abstentions by Algeria, Belarus, Indonesia, Libya, and South Africa, 'sixteen member countries of the NAM were present at the voting; the result shows that not only did the NAM fail to build support for Iran, but even India, Russia, and China, which were major members of the Eastern bloc, supported the resolution and voted against Iran.' Mousavian, p. 226.

41 ElBaradei expressed his regret after the November 24, 2005 vote that the resolution had not passed with consensus in the Board 'as is customary'.

42 These are summarised by Mousavian, pp. 226–227.

43 John Carlson, 'Defining Noncompliance: NPT Safeguards Agreements', *Arms Control Today*, Arms Control Association, May 2009. Available at: www.armscontrol.org/act/2009_5/Carlson

44 Private communications by former IAEA and member state officials, July and August, 2015.

45 Paragraph 19 of INFCIRC/153 states that, if the IAEA Board of Governors, 'upon examination of relevant information reported to it by the Director General finds that the Agency is not able to verify that there has been no diversion of nuclear material . . . to nuclear weapons or other nuclear explosive devices,' the Board may report the matter to the UN Security Council.

46 Mark Hibbs, 'Iran plant disclosure may prompt IAEA to focus on weapons data,' *Nucleonics Week* 50:39, October 2009. pp. 1, 12–14.

47 'Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran', GOV/2011/65, International Atomic Energy Agency, November 2011. Available at: www.iaea.org/sites/default/files/gov2011-65.pdf

48 'Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System: Proposals for Implementation under Complementary Legal Authority', GOV/2863/Corr.1, International Atomic Energy Agency, May 1996. Available at: www.iaea.org/About/Policy/GC/GC40/Documents/gov2863.html

49 Michael D. Rosenthal, Lisa L. Saum-Manning, Frank Houck. p. 46.

50 See: GOV/2006/14. Emphasis added.

51 S/RES/1696 (2006), UN Security Council, July 2006. Available at: www.securitycouncilreport.org/atf/cf/%7B65BFCF9B-6D27-4E9C-8CD3-CF6E4FF96FF9%7D/Iran%20SRES1696.pdf

52 Private communication, former US government official, September, 2015.

53 Mark Hibbs, 'Amano's Move on Marivan', Carnegie Endowment for International Peace, December 2014. Available at: carnegieendowment.org/2014/12/17/amano-s-move-on-marivan

54 See: 'Communication dated 27 August 2007 from the Permanent Mission of the Islamic Republic of Iran to the Agency concerning the text of the 'Understandings of the Islamic Republic of Iran and the IAEA on the Modalities of Resolution of the Outstanding Issues', INFCIRC/711, International Atomic Energy Agency, August 2007; and 'IAEA, Iran Sign Joint Statement on Framework for Cooperation', IAEA News Centre, November 2013, respectively.

55 Hibbs (2014).

56 IAEA GOV/2784 from February 21, 1995, 'Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System' spelled out that the IAEA sought 'improved analysis and evaluation of all relevant information available to the agency' for making safeguards judgments (p. 5). Under the rubric 'Broader Access to Information,' GOV/2784 cited as the IAEA's goal: 'Information from all sources available to the Agency, including the public media, scientific publications and existing Secretariat databases (power reactors – PRIS, research reactors – RRDB, fuel cycle facilities – NFCIS and the International Nuclear Information System – INIS), as well as other information made available by Member States.' GOV/2784 also explained that the information would be used to develop a physical model called the proliferation critical path 'describing all known pathways (combinations of processes) for the production of weapons-usable material and weaponisation.' 'Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System', GOV/2784, International Atomic Energy Agency, February 1995.

57 Victor Bragin, John Carlson, and Russell Leslie, 'Integrated Safeguards: Status and Trends', *The Nonproliferation Review*, Vol. 8, No. 2, 2001. pp. 102–110.

58 'IAEA Safeguards Glossary: 2001 Edition', *International Nuclear Verification Series*, No. 3, International Atomic Energy Agency, June 2002.

59 'The Conceptualization and Development of Safeguards Implementation at the State Level,' GOV/2013/38, International Atomic Energy Agency, August 2013. para. 12.

60 Mark Hibbs, 'The Plan for IAEA Safeguards', Carnegie Endowment for International Peace, November 2012; Mark Hibbs, 'Russia's Safeguards Problem', Carnegie Endowment for International Peace, December 2012; and Laura Rockwood, 'The IAEA's State-Level Concept and the Law of Unintended Consequences', *Arms Control Today*, August 2014.

61 Russia, beginning in 1995, raised concerns in the board about the objectivity of IAEA safeguards should the IAEA's use of third-party information expand.

62 Michael D. Rosenthal, Lisa L. Saum-Manning, Frank Houck (2010). p. D.

63 In 2009, NAM countries represented on the board prevented agreement on an IAEA plan for an international fuel bank, on the grounds that the IAEA should not be proposing initiatives intended to discourage developing countries from exercising their NPT Article IV rights. 'Developing countries block IAEA plans for n-fuel banks', *Hindustan Times*, 18 June 2009. Available at: www.hindustantimes.com/world-news/developing-countries-block-iaea-plans-for-n-fuel-banks/article1-422878.aspx

64 Private communications, IAEA member state officials and former IAEA personnel, October–November, 2015. 'The Secretariat kept reiterating that the SLC was all about safeguards implementation, so there was no obligation on the [Department of Safeguards] to inform the board about what they were doing,' one IAEA governor said.

65 Jill N. Cooley, 'Progress in Evolving the State-level Concept', Seventh INMM/ESARDA Joint Workshop: Future Directions for Nuclear Safeguards and Verification, October 2011. Available at: www.inmm.org/AM/Template.cfm?Section=Evolving_the_IAEA_State_Level_Concept&Template=/CM/ContentDisplay.cfm&ContentID=2965

66 'Implementation of the NPT Safeguards Agreement and Relevant Provisions of Security Council Resolution 1737 (2006) in the Islamic Republic of Iran', GOV/2007/8, International Atomic Energy Agency, February 2007.

67 'Safeguards Implementation Report for 2012', GOV/2013/20, International Atomic Energy Agency, April 2013. p. 46.

68 'Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran', GOV/2005/67, International Atomic Energy Agency, September 2005.

69 'The IAEA's State-Level Concept and the Law of Unintended Consequences' (2014); Olli Heinonen, 'The Iranian Nuclear Programme: Practical Parameters for a Credible Long-Term Agreement', The Henry Jackson Society, November 2014. p. 21.

70 'Communication dated 20 November 2014 received from the Permanent Mission of the Islamic Republic of Iran to the Agency regarding the Report of the Director General on the Implementation of Safeguards in Iran', INFCIRC/871, International Atomic Energy Agency, December 2014.

71 'The Iranian Nuclear Programme: Practical Parameters for a Credible Long-Term Agreement' (2014), p. 8.

72 Early in the Iran crisis, the United States adopted the position that one key outcome to a negotiated settlement should be 'zero enrichment' by Iran. During the initial phase of the negotiation of the JCPOA, some US officials asserted that the agreement would include the obligation by Iran to accept 'anytime, anywhere' inspections.

73 Oliver Meier, 'In der Krise liegt die Chance; Der Atomkonflikt mit Iran und seine Auswirkungen auf das nukleare Nichtverbreitungsregime', Stiftung Wissenschaft und Politik, October 2014. p. 13.

74 Private communications, Western country JCPOA negotiators, September 2015.

75 Pierre Goldschmidt, 'IAEA Safeguards: Dealing preventively with non-compliance,' Belfer Center for Science and International Affairs, July 2008. Available at: belfercenter.ksg.harvard.edu/publication/18456/iaea_safeguards.html

76 In August 2015, it was made public that the IAEA and Iran had reached confidential understandings concerning IAEA access to a military base at Parchin, which had been cited by IAEA member states in communications to the secretariat as a suspected location for nuclear weapons-related activity. Iran and the IAEA agreed to some technical verification measures at Parchin which were not routine. The point is that, in advance of performing verification as called for by the JCPOA's timetable, the IAEA and Iran had negotiated confidential agreements about how they would proceed in detail to resolve this issue. According to diplomatic sources, the IAEA and Iran have likewise negotiated other understandings about how to resolve other issues in the 'Roadmap' requiring clarification for Iran to comply with its obligations under the JCPOA.

77 Private communication, former IAEA safeguards official, June 2012.

78 'The Iranian Nuclear Programme: Practical Parameters for a Credible Long-Term Agreement' (2014). p. 22.

79 Data from the IAEA Programme and Budget for 2016 and from recent Safeguards Implementation Reports suggest that total safeguards expenditure for Iran for 2016 might approach EUR 18 million, which is the amount spent in recent years in Japan. Prior to conclusion of the JPA and then the JCPOA, the cost of safeguards implementation in Iran in 2012 was EUR 12.5 million.

80 Russian officials said that during board meetings Russia underlined the essential difference between the IAEA's routine safeguards mandate and its unique mandate in Iran. Private communication, November 2014.

81 'EU Statement – United Nations General Assembly: Report of the IAEA', European Union Delegation to the United Nations, November 2014. Available at: eu-un.europa.eu/articles/en/article_15688_en.htm.

82 Private communication, Western government safeguards policy official, October 2014.

83 Private communication, JCPOA negotiator, September 2015.

84 Research and discussion is ongoing about what technologies, dual-use items, materials, and activities might be included on such a no-weaponisation 'checklist,' and some observers have advocated that the list of proscribed activities for Iran be adopted by all NPT non-nuclear-weapon states. Dr Viatcheslav Kantor (eds.) *The Limits of Secure Nuclear Tolerance*, International Luxembourg Forum on Preventing Nuclear Catastrophe, 2014. Available at: www.luxembourgforum.org/eng/Forums_Library/items/Book%20by%20VVK%202014_eng.pdf

85 For example, Rolf Ekeus proposed that a subsidiary organ of the UN Security Council be empowered to handle weaponisation-related allegations, leaving the IAEA in charge of matters concerning nuclear materials, in *Ibid*., p. 27.

86 *Ibid.*, p. 36.

CHAPTER 2

Securing the front end of Iran's fuel cycle

Andreas Persbo and Hugh Chalmers

Introduction

On 14 July 2015, Iran agreed to a Joint Comprehensive Plan of Action (JCPOA) with the permanent members of the United Nations Security Council, the European Union and Germany. In return for sanctions relief, the country pledged to downsize its nuclear ambitions and put large swathes of its nuclear fuel cycle under international monitoring. This agreement promises to put a long-running nuclear standoff between Iran and most of rest of the international community to rest.

As a consequence, Iran may find itself normalising its relations with much of the rest of the world, and it may see its economy recovering as trade starts to flow. However, that future hangs by a single hair of a horse's tail. Should Iran be suspected of straying from the deal at any stage, it may find sanctions reapplied, confounding most hopes of normal trading relations. At that stage, Iran could be pushed into seriously considering acquiring nuclear weapons. This possibility alone would stoke fears over Iran's nuclear ambitions, in turn elevating the possibility of armed conflict.

Against that backdrop, all parties to the JCPOA have a strong incentive to make the agreement successful. However, given recent history, parties also have reasons to distrust each other (see Chapter 1 by Mark Hibbs). The complicated deal, with its many reversible provisions, should be understood from that perspective. Its unique verification and monitoring provisions are a reflection of the distrust of the West, and the willingness of Iran to assuage those concerns, at least partially.

The International Atomic Energy Agency (IAEA) will play a central role in JCPOA implementation, despite not being a party to the negotiations themselves. The majority of the restrictions in the agreement will be verified through the application of established IAEA mechanisms, in particular through Iran's Comprehensive Safeguards Agreement (CSA) and the Additional Protocol.

However, the JCPOA will also increase the level of detail in IAEA accountancy in the industrial processes of mining, milling and conversion of uranium ore; which is sometimes referred to as the 'front end' of the nuclear fuel cycle. Accounting for Iran's source material aims to cut off the country's ability to develop and use clandestine enrichment and reprocessing facilities. These activities constitute the two possible routes for any country to build a domestic capacity for producing weapons-usable material). While it would be possible for the country to build such plants, they cannot operate without nuclear material. Iran cannot use materials that are accounted for by IAEA safeguards in such facilities. It would need to find them elsewhere, either through diverting its domestic supplies or through clandestine import.

This chapter will describe the front end of Iran's nuclear programme. It will outline existing verification measures applicable to it, and explore additional safeguards steps. It will conclude by offering a reflection on how well existing and proposed steps may constrain the country's ability to operate a clandestine fuel cycle.

The JCPOA

Iran's nuclear programme has grown substantially over the last decade. In 2004, it maintained modest small-scale capabilities. The debate then focused on persuading Iran to give up its enrichment programme in its entirety.[1] These efforts proved to be in vain. Ten years later, the country had put into place two working gas centrifuge enrichment facilities, and appreciably expanded the front end of its nuclear fuel cycle. However, despite this growth its assets remain meagre compared to many other countries with nuclear industries.

The country's fuel cycle is under-dimensioned for the purpose of supporting its civilian nuclear industry. However, it is adequately sized for a small weapons programme.[2] Information on Iran's activities—including facts verified by the IAEA and details alleged by some of the organisation's member states—remains concerning. Today, the country has developed a 'uranium route' that could be exploited for a nuclear explosive programme, complete with mines, conversion capabilities as well as the ability to enrich moderate amounts of uranium to weapons-grade level. The country's capacity to fabricate weapons components is less clear—and information pointing to such abilities remains largely unverified. On balance, however, Iran appears to have a basic capability to assemble fissionable material into compressible hemispheres. Moreover, the country is alleged to have conducted tests on high explosives and lens systems, and is confirmed to have tinkered with neutron initiator components.[3] All these processes are prerequisites for building a nuclear weapon, and all this information points to a potential military use of fissionable material—possibly by having used undeclared stocks (or intending to use them in the future). Therefore, the IAEA is obliged to follow up on the information, despite it being mostly unconfirmed.

The JCPOA aims to cut off all pathways through which Iran can acquire weapons. It focuses on monitoring the production and stockpiling of fissionable material rather than conclusively establishing what transpired in the programme's past. The agreement's emphasis on the future is its main strength, but also its principal weakness. It is not possible to produce nuclear explosive devices without access to fissile material, so the focus on achieving a comprehensive account of Iran's material balances is, from that perspective, a wise strategy. However, a lack of a firm understanding of what transpired in the past will make it harder to reach a broader conclusion that all nuclear material in a state has remained in peaceful activities, that is, that the state declaration is both complete and correct.

The agreement will effectively shut off Iran's ability to produce weapons-grade plutonium. The document calls for a redesign and rebuild of Iran's existing reactor—located near Arak—and sets out that it should use 3.76 per cent enriched fuel. An international partnership will certify the new design, and all spent fuel will be shipped out of the country, preventing domestic reprocessing. Moreover, Iran will cease production of heavy water and export whatever stocks it may hold in excess.[4]

The agreement focuses on Iran's burgeoning enrichment capabilities, which is not surprising given that enrichment constitutes the country's most established (as well as its fastest) pathway to a nuclear explosive device. The JCPOA limits Iran's ability to produce weapons by establishing a hard ceiling on Iran's enrichment capability for the period 2015–2023, after which the country is free to expand at a 'reasonable pace.'[5] So what is that ceiling? Until 2025, Iran is limited to using 5,060 early-generation gas centrifuges at one main facility—located near Natanz—while also keeping its stockpile of enriched hexafluoride gas to below 300 kilograms (enriched to 3.67 per cent in the isotope uranium-235).[6]

The assumed objective for Western negotiators has been to keep the time needed for Iran to produce enough fissionable material for one nuclear weapon—sometimes referred to as the 'break-out' time—to less than one year. The hard ceiling appears to meet this objective while allowing Iran to continue some of its nuclear activities. However, considerable uncertainties remain. For instance, the actual capability of the installed centrifuge design is not known.[7] Other uncertainties also remain: for instance, the tails settings (that is, the uranium depletion ratio in the waste-product) could have a deciding influence on the enriched uranium production rate, and consequently the breakout time.

Accounting for Iran's fissionable material, and putting its facilities under surveillance, should dramatically reduce—or eliminate completely—the appeal of using safeguarded material for weapons purposes. To avoid detection, Iran would need to use undeclared stocks of fissile material in undeclared facilities. Some JCPOA provisions aim to address this risk: remaining centrifuge components, for instance, are required to be placed in containment, and under surveillance. The agreement puts into place a challenge inspection regime, which allows the IAEA to visit any site in the country, albeit after a 24-day delay. Moreover, the application of the Additional Protocol should enable the agency to draw a broader conclusion that all materials that should have been disclosed have in fact been declared as required. Finally, and perhaps most importantly, enhanced monitoring measures on the front end should make it more time-consuming, and overall more costly, for Iran to acquire the necessary feed material.

The front end of Iran's nuclear programme

The most important task facing a country seeking nuclear weapons is getting hold of enough fissionable material.[8] Uranium exploration is a costly and resource-intensive industrial process. To date, two elements have been used in nuclear weapons: element 92 (uranium) and element 94 (plutonium). Three principal isotopes are useful in a weapons design: uranium-233, uranium-235, and plutonium-239.[9] Natural uranium contains about 0.7 per cent uranium-235 and 99.3 per cent uranium-238, in addition to traces of other isotopes. Uranium containing more than 20 per cent of uranium-235 is considered weapons-usable.[10]

Uranium route

Uranium ore needs to undergo extensive refinement before it can be used to fuel a weapon. For instance, and as will be noted below, Iran has declared that it may be able to produce ore containing roughly 250 kilograms of uranium per day. Of that, 1.75 kilograms would be in the isotope 235. The metal would need to contain about 50 kilogrammes in the isotope 235 to be directly usable in a nuclear explosive device. The ratio of fissile isotopes in the metal would, in other words, need to be improved by several orders of magnitude; and this is accomplished through the industrial process referred to as enrichment.

Uranium—plutonium route

Uranium can also be transmuted into plutonium, which is more directly usable in nuclear explosives. Bombarding uranium metal with neutrons creates plutonium-239, and this transmutation is a natural process occurring in nuclear reactors. From time to time, the uranium-238 will capture a neutron and increase its weight, transmuting into plutonium-239. However, if the fuel is left in the reactor too long, it risks becoming less appealing to a weapons manufacturer. From time-to-time, plutonium-239 captures another neutron, transmuting further into plutonium-240, which, although theoretically usable, is an undesirable isotope from a weapons design perspective.

When producing high-quality material for weapons, it is for these reasons preferable to use natural uranium fuel (which has a high uranium-238 content) as this maximises the production of plutonium in the isotope 239. Moreover, the amount of material undergoing fission in the reactor would need to be kept low, to minimise the production of the isotope 240. Iran's heavy-water reactor near Arak would have been perfectly suitable for this type of production. That is why the JCPOA stipulates that the Arak facility is to be converted to a type using slightly enriched fuel. Since this is scheduled to happen within the next few years, this paper will not examine potential diversion paths to the Arak plant.

Uranium imports

To date, Iran is likely to have relied on nuclear material imported from abroad to supply its nuclear fuel cycle. The country is known to have imported around 600 metric tonnes of yellowcake—a uranium concentrate powder—from South Africa in the 1970s. Over the years, this moderate stockpile may have been significantly depleted.[11] At the same time, Iran's effort to develop its indigenous sources of uranium has been slow. The lack of stocks would have forced the country to seek additional supply on international markets.

There has been no absence of speculation in the press about Iranian forays into bulk yellowcake acquisitions. Reports in 2013 about a potential uranium deal with Zimbabwe led to strong denials from the government of President Robert Mugabe.[12] According to the OECD/IAEA 'Red Book', Zimbabwe's uranium reserves are small, undeveloped, and expensive to extract; Chinese companies carry out most exploration in that region of Africa.[13] Press accounts have, moreover, claimed that Iran may seek to import uranium from the Rössing mine in Namibia, in which it holds a small financial stake. The mine has been in operation since July 1976, and has since excavated over 104,000 tonnes of uranium.[14] However, the site's operator has denied any supply deal with Iran.[15] Finally, reporting by Associated Press in 2009 alleged that Iran had tried to acquire 1,350 metric tonnes of yellowcake from Kazakhstan, the world's largest producer of yellowcake. The Kazakh government denied this report, but it is clear that it took the press account seriously, as it shortly thereafter launched an in-depth review of its uranium extraction regulations.[16]

Iranian dignitaries have also been known to visit uranium-producing countries such as Niger and Malawi.[17] While all reports of potential purchases have been denied, the prospect of an Iranian import of source material seems to be high on many suppliers' minds. Moreover, if Iran has indeed been shopping on international markets, it would appear that other international actors have forestalled its attempts.

Domestic uranium mining and milling

If the import route appears closed to Iran, it will make sense for it to try to exploit whatever domestic resources it may have available. Indeed, over the past five years, Iran has invested heavily in uranium exploration in an attempt to uncover further resources. It operates two mines, but one—Gachin—may already be heavily exploited, and is likely to be depleted at some point over the coming decade. The other—Saghand—has been under development for years and the status of operations at the site is unclear.

Gachin is a salt plug where uranium is recovered by open-pit mining. The ore grade is low—by Iran's admission some 800 parts per million (ppm) and declining.[18] The country estimates that about 100 tonnes of uranium can be recovered from the site, and the majority of that should have been extracted by now. The ore is taken from the mine to a facility called the Bandar Abbas uranium plant (BUP), which is capable of processing about 70 tonnes of uranium ore—containing about 50 kilograms of uranium—per day. This plant has been in operation since 2006.[19] Satellite imagery would suggest, however, that mining activities started in earnest in early 2010.

Saghand operates both open-pit and underground mining. The latter contains two main shafts—one main and one for ventilation—and adits and stopes are being continuously developed.[20] The ore grade in this mine is 500 ppm, and the country estimates to recover 900 tonnes of uranium from the site. Iran has built a much larger facility, the Ardakan production centre, to handle ore from this mine. It is capable of processing about 400 tonnes of ore per day, containing between 200 and 220 kilograms of uranium. The plant reportedly went into operation in 2013.[21]

Iran's total stockpile of uranium yellowcake, domestically and internationally sourced, can, therefore, be estimated to be somewhere between 600 and 700 tonnes—and much of that appears to have been converted into uranium hexafluoride (see below).[22] It may double that stockpile in the coming decade if their mining operations go to plan. After that, it would need to exploit new fields. Iran's reliance on domestic supply helps explain the emphasis in the JCPOA on establishing some degree of accountancy on the front end of the nuclear fuel cycle. But as will be discussed below, how to do that is not entirely clear.

Uranium conversion

Before enrichment and reactor operations can commence, the yellowcake would need to be further processed. Iran is doing this work at a uranium conversion facility at the Esfahan Nuclear Technology Centre (ENTC). The facility processes the yellowcake into natural uranium hexafluoride—a feedstock for subsequent enrichment—as well as uranium dioxide. It has an annual capacity of about 200 metric tonnes of uranium hexafluoride gas per year. The facility is also scheduled to produce uranium tetrafluoride as well as uranium metal ingots from natural and depleted uranium tetrafluoride. Since the plant started to operate, it has produced 550 metric tonnes of natural uranium hexafluoride, of which 185 tonnes have been shipped for subsequent enrichment.[23]

Verifying the front end of Iran's nuclear programme

Article 33 of Iran's safeguards agreement makes clear that accountancy does not apply to material in mining or ore processing activities.[24] Article 34 of the agreement defines the starting point of safeguards. Iran must report imports and exports of yellowcake for nuclear purposes to the agency.[25] The declaration must contain information on the quantity and composition of the material, and an export declaration must also declare the destination of the shipment. The import and export statement enables the agency to match the quantity with a corresponding declaration submitted by another member state.[26]

Accountancy, however, starts when material with a composition and purity suitable for fuel fabrication or for isotopic enrichment either leaves the plant or the process stage in which it has been produced.[27] Until 2003, this requirement was interpreted so that only final products of the conversion process were subject to safeguards.[28] However, for the last decade, the agency has applied safeguards at the 'first practical point' before the material *within* the conversion process achieves the required purity. In some of these cases, the agency notes, this point might be the yellowcake input at the beginning of the conversion process.[29] Normally, drums of yellowcake transported to and stored in the receipt area of the conversion plant would not be under any specific material accountancy. However, a drum would need to be weighed and assayed once removed from its storage and transferred to the hopper, from where it then enters the dissolution process.

Under the Additional Protocol, activities in a conversion plant would, in some cases, also be subject to so-called complementary access[30] by the IAEA to parts of the site, and in all cases should the facility hold a uranium weight exceeding ten metric tonnes.[31] Permitted activities include visual observation, examination of records relevant to the quantities, origin and disposition of nuclear material, environmental sampling, non-destructive measurements and sampling. Such activities are carried out with very short notice.[32]

The Additional Protocol covers most of the front end of the fuel cycle. Under it, Iran must report the location and operational status of all domestic mines, alongside their current annual and estimated future production figures.[33] As noted above, storage of yellowcake with a *uranium* weight exceeding ten metric tonnes must be reported in all circumstances.[34] However, detailed material accountancy still does not apply to uranium ore, ore concentrates or residue.[35]

Moreover, the agency has the right to get complementary access to mines on giving 24-hour notice.[36] On average, Iran should expect at least one request per mine per year. These inspections usually start with a pre-activity briefing, followed by a host presentation on the present status of the mine. Inspection activities include a facility walk-through and a visual examination of site infrastructure. The agency will take both environmental samples and conduct a non-destructive assay of selected items. The site operator should prepare to give inspectors product samples, as well as allow sampling of in-process material. Finally, inspectors will examine production records, get information on current operations, and may also examine the site's reagent consumption.[37]

The JCPOA goes beyond this. The reference to *containment* in the agreement suggests that the IAEA is required to establish continuity of knowledge on items on the front end of the fuel cycle, such as drums of yellowcake.[38] The reference to *surveillance* suggests that agreed facilities, containers or equipment should be subject to inspector observation, or through monitoring by various pieces of instrumentation, such as cameras.[39]

Specifically, the JCPOA states that the agency should monitor 'that *all* uranium ore concentrate produced in Iran or obtained from any other source, is transferred to the uranium conversion facility at Esfahan (emphasis added)'.[40] The agreement makes clear that all output from Iran's mines are required to be transferred to one location, and nowhere else, and this also applies to imported material. The emphasis on completeness indicates that stronger safeguards measures may be required than is usual in other safeguarded states.

Under the JCPOA, Iran also needs to supply 'all necessary information' needed to 'verify the production of the uranium ore concentrate and the inventory of uranium ore concentrate.'[41] In other words, as Iran's total stock of uranium ore concentrate is subject to verification, it would in all likelihood be subject to accountancy. The JCPOA does not appear to limit itself to simply enabling the agency to form a rough picture of the size and composition of Iran's front end. Instead, the provisions seem to call for detailed accountancy of Iran's yellowcake at a point well before it fulfils the requirements of Article 34 of the country's safeguards agreement.

While Iran would be treated as a special case, with accounting procedures applied on the so-called pre-34 (c) material, it would not be the only country applying safeguards on uranium ore concentrates (UOC). A recent agency policy paper says that: 'some concentration plants have produced UOC of such composition and purity that it meets the relevant purity requirements of industry standards for uranium dioxide fuel fabrication'[42] In other words, the concentrate contains so few impurities that it does not have to go through uranium conversion. In those cases, comprehensive safeguards—including material accountancy—apply on uranium ore concentrate.

Cindy Vestergaard argues, in her book *Governing Uranium*, that 'the international safeguards system is thus shifting upstream, capturing more materials at the front end of the nuclear fuel cycle.' She cautions, however, that the policy 'has yet to be fully implemented, and its success in addressing gaps in the control of natural uranium will be determined in the years to come.'[43]

Implementing front end transparency measures under the JCPOA

Iran would need to take some practical steps to fully implement the JCPOA. The exact arrangements will be kept confidential, as is the case under IAEA safeguards. However, it is possible that the following steps may be considered by the IAEA and Iran.

First, Iran would need to designate areas where yellowcake is stored. These areas are likely to be one—or perhaps several—buildings containing 200-litre drums filled with uranium concentrate. At a site visit, inspectors would confirm that all produce of the plant is stored at that location. While this may sound like a time-consuming task, it is worth recalling that Iran's mines are relatively small compared to major ore producers. Depending on how well the drums are filled, and the density of the concentrate itself, the content of each drum is expected to weigh between 500 to 650 kilograms.[44] In other words, Iran's annual output of ore—from both mines—would fit into no more than 200 drums filled to 500 kilograms.[45]

Canada, a major uranium mining country, requires that all license holders of so-called Group 2 material maintain an 'Inventory Change Document' and an 'Obligated Material Inventory Summary' for uranium ore and uranium ore concentrates.[46] The license holder needs to report inventory changes to the regulator on the business day following the transaction. The holder needs to submit an inventory summary annually on 31 January, or at any time at the regulator's request.[47] Canada has started to implement an electronic reporting system, which facilitates near-real-time reporting of balances to the IAEA.[48] Iran could usefully implement a similar system for its extractive sites.

In addition, each drum of concentrate should be individually coded and sealed. Modern bar code tagging should be applied. A wide variety of seals can be used, and their suitability depends on other installed surveillance options. If the warehouse itself is placed under camera surveillance, simple wire-loop seals can be considered. Otherwise, more reliable equipment can be applied, such as fibre-optic seals.

If the mill ships a barrel of ore concentrate to Esfahan, it would need to submit an inventory change document to the regulator, who would forward it to the IAEA. Once the conversion facility receives the drum, it would need to fill in a corresponding receipt. At that time, the coding should be checked to confirm that it matches the record at the mill (and if there is a barcode, this can be done electronically). The integrity of the seal should also be checked to make sure that no concentrate has been removed or added. Finally, the drum is placed in monitored storage at a warehouse in Esfahan. The IAEA will have near real-time data on these transactions if Iran puts in place a computer based system similar to that deployed by the Canadian nuclear regulator.

What are the diversion risks associated with a scheme like the one outlined above? One significant quantity of natural uranium is ten metric tonnes. In order to divert this much material, Iran would need to divert at least 20 barrels—or one tenth of its annual output. A diversion this scale is, for comparison, on the order of 100 magnitudes greater than the acceptable uncertainty in Australia's (another major uranium producer) accountancy system for uranium ore concentrate.[49] Detection within one year, the agency's typical timeliness detection goal, is virtually assured.

As noted above, the JCPOA requires that '*all* uranium ore concentrate produced in Iran . . . is transferred to the uranium conversion facility (UCF) in Esfahan [. . .]'.[50] Any other form of transfer would be breaking the terms of the arrangement. The above outlined verification protocol would enable the agency to detect any unauthorised transfer very quickly.

Verifying uranium ore concentrate inventories

Under the JCPOA, Iran should provide the agency with *'all necessary information* such that the IAEA will be able to verify the production of the uranium ore concentrate and the inventory of uranium ore concentrate produced in Iran or obtained from any other source for 25 years.'[51] It is not clear how much information Iran is required to give out.

The total inventory of the stockpile of uranium ore concentrate should naturally be reported, and so should its level of concentration. However, it is not clear how frequently Iran should submit this information. As noted above, it is possible to implement a regime that enables near-real time reporting on inventory levels. It is left to Iran and the agency to agree on the desired level of monitoring.

Iran should be able to furnish verifiable data on the quantity and composition of the yellowcake in each drum. The data could then be verified through, for instance, weighing and non-destructive assaying. While operator supplied scales could be used, it is preferable for the IAEA to use authenticated equipment, such as the 'load cell based weighing system'.[52]

Further checks can be introduced on the yellowcake. Destructive assay techniques, such as 'inductively coupled plasma mass spectrometry' (ICP-MS) in particular, can determine most elements down to parts per billion.[53] Deploying such equipment to the uranium mills, or regularly bringing samples to a qualified laboratory, will enable the agency to get a very comprehensive picture of the impurity content of any batch of uranium ore concentrate. However, it goes beyond that. A sampling regime involving ICP-MS could potentially allow for the content of any individual drum of yellowcake to be matched to a specific mine.[54]

All proposed measures above focus on the finished uranium ore concentrate product. But another possible diversion scenario would involve Iran misleading inspectors about the amount of ore *going into* the mill (or the uranium weight in the ore itself), and consequently underreporting the amount of produced concentrate. However, keeping the mill under continuous surveillance by, for instance, deploying some next generation surveillance system (NGSS) cameras to the mill, could minimise the risk that this scenario occurs. The NGSS collects visual evidence through a networked set of cameras. Images are sent back to a 'consolidator unit' (a databank), which—if Iran agrees—can transmit the data back to Vienna. Public key encryption protects the data.[55]

Ore could also be shipped to a clandestine mill. This would be harder to detect. However, the JCPOA allows for short-notice inspections of suspected undeclared mills. Moreover, space surveillance and other national technical means are likely to provide strong indicators of where clandestine milling may occur.[56]

Even if domestic production of uranium ore concentrate is subject to robust safeguards, the possibility remains that Iran may clandestinely import material. At the moment, exports to Iran are restricted through a set of UN Security Council resolutions.[57] These resolutions will be lifted as the JCPOA goes through implementation. The onus will remain on exporting states to ensure that their exports are reported to the agency in accordance with the export rules in their safeguards agreements.

Monitoring the conversion to uranium hexafluoride

Eventually, the yellowcake will need to be shipped to the conversion plant at the ENTC. At some point in this process, detailed nuclear material accountancy measures will start to apply. Nuclear material leaving the plant is likely to have reached 'a composition and purity suitable for fuel fabrication or for being isotopically enriched.'[58] In Iran's case, the main product of concern is natural uranium hexafluoride, which can be used in subsequent enrichment processes. Uranium hexafluoride is versatile, at atmospheric pressure it remains solid until it is heated to about 50 degrees Celsius, at which point it sublimes into gas. This allows it to be used in centrifuges. The compound is usually stored in standard steel drums—designated 48T through G—that have a fill limit of 9.3 to 12.1 metric tonnes of uranium respectively.[59] Overfilling the drums can lead to severe accidents, possibly rupturing the tank when the material sublimes. The enriched material has to be stored in smaller drums.

The IAEA will always account for the final products of the conversion process (that is uranium hexafluoride, uranium tetrachloride, metallic uranium or uranium dioxide). Until 2003, the feed itself was not subject to any safeguards procedures.[60] Inspectors arriving at a plant would weigh and assay the product, but not do any corresponding verification in the feed areas of the plant. A plant operator could theoretically keep two books. The one examined by the inspectorate could understate receipts of yellowcake—opening up the possibility of clandestine production.

For the last decade, however, material accountancy at conversion plants has begun at the 'first practicable point' in the conversion process, in some cases where the uranium concentrate itself is inputted.[61] In most states, the drums of yellowcake themselves are not subject to any safeguards procedure. Accountancy starts when the drums arrive at the conversion plant. As noted above, there is an emerging exception to this rule. The IAEA has recently been considering moving the starting point of safeguards further to the front of the nuclear fuel cycle.

Uranium conversion is the stage where the nuclear material becomes more tangible and identifiable. This allows for the material to be identified, counted, and where appropriate, sealed. The main difficulty with verification in conversion plants, as in mines, is that the quantities may be large, although this may not be a major factor in Iran at the moment. The material not being especially toxic at this stage, and as criticality risks are non-existing or low, material is easy to remove at any stage.[62]

As noted above, the Iran's conversion facility has a stock of about 365 metric tonnes of natural uranium hexafluoride. The JCPOA states that Iran can hold a total enriched uranium stockpile of no more than 300 kilograms of up to 3.67 per cent enriched uranium hexafluoride.[63] The remainder should be down-blended to natural uranium or sold on international markets.[64] The hard ceiling means that approximately two metric tonnes of natural uranium hexafluoride—less than half a per cent of Iran's available stock—can be used for enrichment purposes, and the rest would need to be held back in storage.

The 48Y-type cylinder—a standardised container used to store uranium hexafluoride—has a maximum fill limit of 12,500 kilogrammes.[65] Iran's presently unshipped stockpile is, therefore, likely to be stored presumably on site in more than 30 cylinders. Another 15 cylinders of down blended material are likely to be added to this stock in the coming year. Given the hard inventory ceiling, this stockpile is unlikely to change much over the coming years, and so should be relatively easy to verify.

In 2012, the IAEA approved the 'Laser Item Identification System' (L2IS) for safeguards use.[66] The system is designed for keeping track of the movement of cylinders in enrichment plants, but could equally be used in conversion facilities. The system has two units. A portable unit allows the inspectors to 'fingerprint' all cylinders that the operator intends to use over a period of time. It does so by reading the micro-structure of each drum's surface. A stationary unit—placed at strategic entry and exit corridors—then scans cylinders as they pass through, comparing the laser-image with the template. The system is hence capable of tracking individual cylinders through their use. Given that Iran's inventory is stored in relatively few cylinders, it should be relatively straightforward to fingerprint all of them.

Conclusion

The JCPOA is a complicated agreement—see Mark Hibbs' chapter in this book—containing many interlocking components. The present chapter has looked at how the agency can introduce stricter monitoring on the front end of Iran's nuclear fuel cycle. Introducing such controls, on a scale envisioned by this chapter, would place Iran's uranium extractive industries under state-of-the-art monitoring. It cannot provide foolproof assurances against clandestine uranium import or extraction, but would radically increase detection probabilities, and would make any attempted diversion of source material more expensive.

In the longer term, more countries are likely to bring their extractive industries under a stronger monitoring framework, and Canada's experience as a major uranium producer serves, from this perspective, as an illustrative example. JCPOA implementation in Iran is, therefore, an opportunity to learn how to conduct front end monitoring in a more effective and, in the long run, more economical way.

For Iran and its JCPOA partners, enhanced front end monitoring is only one aspect of a broader verification package. Nevertheless, establishing a firmer grip on the production and import of source material will make the verification task down-stream in the nuclear fuel cycle far easier. It will also make it easier for the agency to some day reach a broader conclusion that all nuclear material in Iran has been declared as required.

Endnotes

1 See for instance, Kerr, Paul. 'Iran Agrees to Temporarily Suspend Uranium-Enrichment Program.' Arms Control Today. December 1, 2004. Accessed September 25, 2015. www.armscontrol.org/act/2004_12/Iran.

2 This has been discussed in both literature and government statements. See, for instance, Hecker, Siegfried, and Perry, William. 'Iran's Path to Nuclear Peace.' The New York Times. January 9, 2014. Accessed September 25, 2015. www.nytimes.com/2014/01/10/opinion/irans-path-to-nuclear-peace.html?_r=0. And DeSutter. Paula. 'Iranian WMD and Support of Terrorism.' US Department of State. December 17, 2003. Accessed October 16, 2015. 2001-2009.state.gov/t/vci/rls/rm/24494.htm.

3 This information was brought to the public domain by the IAEA in 2011; see 'Implementation of the NPT Safeguards Agreement and Relevant Provisions of Security Council Resolutions in the Islamic Republic of Iran (GOV/2011/65).' International Atomic Energy Agency. November 11, 2011. Accessed September 23, 2015.

4 JCPOA, operative paragraphs 7, 8 and 10.

5 JCPOA, operative paragraph 1.

6 JCPOA, operative paragraphs 2 and 7. Iran's workhorse centrifuge is the IR-1. In the past, these machines have been capable of producing between 0.59 and 0.79 kg/SWU per year. See Persbo, Andreas. 'Progress at Natanz (reposted).' February 27, 2009. Accessed September 28, 2015. www.armscontrolverification.org/2009/02/progress-at-natanz-reposted.html?q=SWU. The agreement also puts limitations on Iran's research and development work. Until 2025, it can only test the already existing series of machines, domestic designations IR-4, 5, 6 and 8, see operative paragraph 3. The enrichment ceiling corresponds to the fuel requirements of Iran's redesigned heavy water reactor.

7 Heinonen, Olli, and Henderson, Simon. 'How to Make Sure Iran's One-Year Nuclear Breakout Time Does Not Shrink.' Policy Watch #2436. June 17, 2015. Accessed September 25, 2015. www.washingtoninstitute.org/policy-analysis/view/how-to-make-sure-irans-one-year-nuclear-breakout-time-does-not-shrink.

8 Fissionable material is a nuclide that is capable of undergoing fission after capturing either high-energy (fast) neutrons or low-energy thermal (slow) neutrons. See 'Fissionable Material.' NRC: Glossary. July 1, 2015. Accessed October 16, 2015. www.nrc.gov/reading-rm/basic-ref/glossary/fissionable-material.html.

9 Fissile material is a nuclide that is capable of undergoing fission after capturing low-energy thermal (slow) neutrons. See 'Fissile Material.' NRC: Glossary. July 23, 2015. Accessed October 16, 2015. www.nrc.gov/reading-rm/basic-ref/glossary/fissile-material.html.

10 The distinction is arbitrary. It is indeed possible to construct a nuclear explosive device using uranium enriched to below 20 per cent in the isotope 235, but it would be very unpractical. The critical mass—the minimum amount of fissile material needed to maintain a nuclear chain reaction—decreases with increasing levels of enrichment. Near infinite amounts of uranium would be required for a device using uranium enriched to less than 5 per cent in the isotope 235. See Forsberg, C.W. and Hopper, C.M. 'Definition of Weapons-Usable Uranium-233.' web.ornl.gov. March 1998. Accessed September 28, 2015. web.ornl.gov/info/reports/1998/3445606060721.pdf.

11 Albright, D, Shire, J, and Brannan, P. 'Is Iran Running out of Yellowcake?' ISIS Reports. February 11, 2009. Accessed August 28, 2015. isis-online.org/uploads/isis-reports/documents/Iran_Yellowcake_11Feb2009.pdf.

12 'Alleged Iranian Uranium Deal With Zimbabwe May Revive Sanctions Debate | GSN | NTI.' NTI: Nuclear Threat Initiative. August 21, 2013. Accessed October 23, 2015. www.nti.org/gsn/article/alleged-iranian-uranium-deal-zimbabwe-may-revive-sanctions-debate/.

13 See *Uranium 2014 Resources, Production and Demand*. Paris: OECD/IAEA, 2014, pp. 20, 33 and 200.

14 See *Uranium 2014 Resources, Production and Demand*. Paris: OECD/IAEA, 2014, p. 324.

15 Iran owns 15 per cent of the Rössing mine. It seems likely that Iran's 1970s import came from here, but the present owner has not explicitly commented on that. See Maletsky, Christof. 'Iran Did Not Buy Uranium from Rössing, Says Govt.' The Namibian, February 1, 2005. Accessed September 28, 2015.

16 Vestergaard, Cindy. Governing Uranium Globally. Copenhagen: DIIS, 2015, pp. 95

17 See 'Iran's Ahmadinejad Visits Uranium-producing Niger.' Reuters. April 15, 2013. Accessed October 26, 2015. http://www.reuters.com/article/2013/04/15/us-iran-niger-idUSBRE93E0RL20130415; and 'Malawi Gets $50m Iran Aid for Mining.' Malawi Nyasa Times. July 29, 2011. Accessed October 26, 2015. www.nyasatimes.com/2011/07/29/malawi-gets-50m-iran-aid-for-mining/.

18 A grade below 1,000 parts per million is characterised as 'low grade'. See 'World Nuclear Association.' Uranium Supplies: Supply of Uranium. September 1, 2015. Accessed September 28, 2015. www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Uranium-Resources/Supply-of-Uranium/.

19 See *Uranium 2014 Resources, Production and Demand*. Paris: OECD/IAEA, 2014, p. 269. If the mill has been going at full capacity since it opened, Iran would have extracted approximately 164 tonnes by now. In other words, far more metal than the mine is supposed to hold.

20 See *Uranium 2014 Resources, Production and Demand*. Paris: OECD/IAEA, 2014, p. 267. An adit is a horizontal passage leading into a mine for the purposes of access or drainage, and a stope is a step-like working in a mine.

21 'Iran Unveils Uranium Activities at Saghand and Ardakan.' BBC News. April 9, 2013. Accessed August 28, 2015. www.bbc.co.uk/news/world-middle-east-22076784. At full extraction rate, the site will be depleted sometime in 2025.

22 This estimate is based on the import of 600 metric tonnes, in addition to mining activity at Gachin starting from about February 2010, and at declared capacity.

23 To produce this, Iran would have used about 60 metric tonnes of fluorine and another 125 metric tonnes of hydrogen fluoride in addition to about 380 metric tonnes of yellowcake.

24 See 'The Text of the Agreement Between Iran and the Agency for the Application of Safeguards in Connection with the Treaty on the Non-proliferation of Nuclear Weapons (INFCIRC/214).' December 13, 1974. Accessed November 2, 2015. www.iaea.org/publications/documents/infcircs/text-agreement-between-iran-and-agency-application-safeguards.

25 INFCIRC/214, article 34 (a) and (b)

26 These are not verified, so it is in theory possible for two colluding countries to understate an export and import declaration, hence giving the impression that *less* material has been transferred. The unreported yellowcake can then be diverted to an undeclared facility.

27 INFCIRC/214, article 34 (c)

28 See paragraph 8 in 'Safeguards Measures Applicable in Conversion Plants Processing Natural Uranium (Policy Paper 18).' *Safeguards Policy Series* SMR 2.18. Vienna: International Atomic Energy Agency, 2003. These materials include uranium hexafluoride or uranium tetrachloride for subsequent enrichment, and metallic uranium or uranium dioxide for fabrication into fuel.

29 Policy Paper 18, paragraph 10.

30 Complementary access—a type of inspection—is provided by the state to IAEA inspectors in accordance with the provisions of an additional protocol.

31 Compare INFCIRC/540, article 2.a.(i) and (ii) and article 2.a.(vi) (a).

32 Policy Paper 18, paragraph 19.

33 INFCIRC/540, article 2.a (v).

34 INFCIRC/540, article 2.a. (vi).

35 INFCIRC/153, paragraphs 33 and 112.

36 INFCIRC/540, articles 4-9.

37 East, Michael. 'Safeguards Reporting and Verification for Uranium Mines.' Lecture, IAEA Training Meeting on Effective Regulatory and Environmental Management of Uranium Production, Darwin, Australia, August 13, 2012.

38 Containment is defined as: 'structural features of a facility, containers or equipment which are used to establish the physical integrity of an area or items (including safeguards equipment or data) and to maintain the continuity of knowledge of the area or items by preventing undetected access to, or movement of, nuclear or other material, or interference with the items. Examples are the walls of a storage room or of a storage pool, transport flasks and storage containers. The continuing integrity of the containment itself is usually assured by seals or surveillance measures (especially for containment penetrations such as doors, vessel lids and water surfaces) and by periodic examination of the containment during inspection.' See *IAEA Safeguards Glossary*. 2001 ed. Vienna: International Atomic Energy Agency, 2002, section 8.1 at p. 66.

39 Surveillance is described as: 'the collection of information through inspector and/or instrumental observation aimed at detecting movements of nuclear material or other items, and any interference

with containment or tampering with IAEA equipment, samples and data. Surveillance may also be used for observing various operations or obtaining relevant operational data. IAEA inspectors may carry out surveillance assignments continuously or periodically at strategic points.' See *IAEA Safeguards Glossary*. 2001 ed. Vienna: International Atomic Energy Agency, 2002, section 8.2 at p. 66.

40 JCPOA, paragraph 68.

41 JCPOA, paragraph 69.

42 *Determination of Uranium Bearing Materials Meeting the Conditions of Paragraph 34(c) of INFCIRC/153 (Corrected) (Policy Paper 21)*. Vienna, Austria: International Atomic Energy Agency, 2013, paragraph 13.

43 Vestergaard, Cindy. Governing Uranium Globally. Copenhagen: DIIS, 2015, p. 48.

44 One typical 200-litre drum holds 218,276 cubic centimetres when filled to the brim; and yellowcake has a density of 2.5 to 3.0 grams per cubic centimetre. See *Production of Yellow Cake and Uranium Fluorides: Proceedings of an Advisory Group Meeting Organized by the International Atomic Energy Agency and Held in Paris, 5–8 June, 1979*. Vienna: International Atomic Energy Agency, 1980.

45 18,250 kg (50 kg × 365 days) or about 37 drums would come from Bandar Abbas and 80,300 kg (220 kg × 365 days) or about 160 drums would come from Saghand. Uranium ore concentrate is rarely 100 per cent pure, so about 15 per cent of the weight would be various other soluble and insoluble material. See page 9 in Marzo, Marco Antonio Saraiva, Lilia Crissiuma Palhares, Fabio Cordeiro Diaz, Marcos Sodré Grund, Ana Claudia Raffo-Caiado, John M. Begovich, Juan J. Ferrada, and Jennifer Ladd-Lively. *Model of a Generic Natural Uranium Conversion Plant—Suggested Measures to Strengthen International Safeguards (ORNL/TM-2008/195)*. Oak Ridge, TN: Oak Ridge National Laboratory, 2009.

46 The regulator defines Group 2 material as 'natural uranium and natural thorium (including ores and ore concentrates) that has not reached the stage in the nuclear fuel cycle when composition and purity is suitable for fuel fabrication or isotopic enrichment.' It states that, in general, 'this material is possessed by mines, mills, concentration plants, and refineries under licence from CNSC.' See section 4.2.2 and 6 in 'Accounting and Reporting of Nuclear Material (RD-336).' Canadian Nuclear Safety Commission. 2011. Accessed November 6, 2015. nuclearsafety.gc.ca/pubs_catalogue/uploads/RD-336_Final_Accounting_and_Reporting_of_Nuclear_Material_e.pdf.

47 RD-336, section 7.

48 Sample, Jennifer. 'Establishing and Advancing Electronic Nuclear Material Accounting Capabilities A Canadian Perspective.' Lecture, IAEA Symposium on International Safeguards: Linking Strategy, Implementation and People, International Atomic Energy Agency, Vienna, October 22, 2014.

49 See Governing Uranium, p. 93.

50 JCPOA, paragraph 68

51 JCPOA, paragraph 69

52 Safeguards techniques and equipment. 2011 edition. Vienna: International Atomic Energy Agency, 2011, p. 38.

53 Safeguards techniques and equipment. 2011 edition. Vienna: International Atomic Energy Agency, 2011, p. 105

54 See, for instance, Keegan, Elizabeth, Michael J. Kristo, Michael Colella, Martin Robel, Ross Williams, Rachel Lindvall, Gary Eppich, Sarah Roberts, Lars Borg, Amy Gaffney, Jonathan Plaue, Henri Wong, Joel Davis, Elaine Loi, Mark Reinhard, and Ian Hutcheon. 'Nuclear Forensic Analysis of an Unknown Uranium Ore Concentrate Sample Seized in a Criminal Investigation in Australia.' *Forensic Science International*: 111-21.

55 Safeguards techniques and equipment. 2011 edition. Vienna: International Atomic Energy Agency, 2011, p. 67

56 After all, the ore would need to be transported. This would lead to vehicular traffic, which is easily picked up by space-based monitoring assets.

57 See, in particular, 'Resolution 1737 (2006) adopted by the Security Council at its 5612th Meeting, on 23 December 2006.' December 23, 2006. Accessed November 20, 2015. www.iaea.org/sites/default/files/unsc_res1737-2006.pdf. See also 'Resolution 1929 (2010) adopted by the Security Council at its 6335th Meeting, on 9 June 2010.' June 9, 2010. Accessed November 20, 2015. www.iaea.org/sites/default/files/unsc_res1929-2010.pdf.

58 'The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-proliferation of Nuclear Weapons.' INFCIRC/153. Accessed September 2, 2015. www.iaea.org/sites/default/files/publications/documents/infcircs/1972/infcirc153.pdf, see paragraph 34 (c).

59 See 'Manual on Safe Production, Transport, Handling and Storage of Uranium Hexafluoride (IAEA-TECDOC-771).' Vienna: International Atomic Energy Agency, November 1994. Accessed October 5, 2015, www.iaea.org/inis/collection/NCLCollectionStore/_Public/28/030/28030673.pdf, p. 41.

60 See Safeguards Policy Series, Number 18. Safeguards Measures Applicable in Conversion Plants Processing Natural Uranium. Vienna: International Atomic Energy Agency, June 2003, paragraph 8.

61 See Safeguards Policy Series, Number 18. Safeguards Measures Applicable in Conversion Plants Processing Natural Uranium. Vienna: International Atomic Energy Agency, June 2003, paragraph 10.

62 'The Present Status of IAEA Safeguards on Nuclear Fuel Cycle Facilities.' IAEA Bulletin, vol. 22, no 3/4, August 1980.

63 JCPOA, Annex 1, paragraph J.56.

64 JCPOA, Annex 1, paragraph J.57.

65 See 'Manual on Safe Production, Transport, Handling and Storage of Uranium Hexafluoride (IAEA-TECDOC-771).' Vienna: International Atomic Energy Agency, November 1994. Accessed October 5, 2015, www.iaea.org/inis/collection/NCLCollectionStore/_Public/28/030/28030673.pdf, p. 41.

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CHAPTER 3

In defence of the evolution of IAEA safeguards

Craig Everton

The safeguards system of the International Atomic Energy Agency (IAEA) for verifying the compliance of states with nuclear non-proliferation commitments is designed to enable the verification tools and methods that it uses to evolve. It is essential that safeguards approaches and methodologies are able to adapt as technologies change, as the risk profile of the nuclear fuel cycle changes, and as the IAEA Secretariat gains more implementation experience—and this all must be done within finite resources. The IAEA's mandate under Comprehensive Safeguards Agreements gives the secretariat flexibility with the tools and methodologies it employs for in-field inspections and headquarters analysis; and in some cases explicitly lists performance-related factors about states that can be used by the secretariat.

A contemporary example of how IAEA safeguards methodologies evolve is the development of 'State-level approaches', implemented under the 'State-level concept'.[1] State-level approaches are a way of incorporating safeguards-relevant information about the whole state in the planning, implementation and evaluation of safeguards activities, rather than being limited to a facility-by-facility approach. State-level approaches have been applied for some fourteen years in certain states, and starting in 2010 the secretariat began work to develop these further for application to all states.

Since 2012 there has been a vigorous debate among IAEA Member States about the State-level concept, with some arguing that it goes beyond the IAEA's mandate and that approval from the IAEA's Board of Governors is required. In response to Member State requests for more information, the IAEA Director General issued a detailed report on the State-level concept in August 2013 and further information in a supplementary document in August 2014.[2] The Director General has also provided assurances that the State-level concept will not introduce any additional rights or obligations, nor modify the interpretations of these provisions.[3] The debate, however, continues.

This paper examines how the foundational principles of IAEA safeguards support the State-level concept, and how the built-in flexibility within the IAEA's mandate supports the methodologies and processes outlined in the Director General's August 2013 and August 2014 reports. The paper will look in particular at the state-specific factors used in developing State-level approaches as these have attracted particular attention in the debate.

The paper examines the State-level concept against the IAEA's mandate under Comprehensive Safeguards Agreements, which apply to 95 per cent of countries. Other types of safeguards agreements, such as those held by nuclear-weapon states or by states not party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), would require different analyses given variations in their terms, so are not considered here.

Comprehensive Safeguards Agreements are known as INFCIRC/153-type agreements as their structure and content is based on IAEA document INFCIRC/153 (Corrected), which was concluded June 1972.[4] Much of this paper draws from the negotiating records of INFCIRC/153. A comprehensive compendium of these negotiations can be found in publicly available references.[5]

IAEA safeguards—foundational principles

For non-nuclear-weapon state parties to the NPT, what is the purpose of the non-proliferation verification regime known as IAEA safeguards? This paper argues that the fundamental and indeed foundational purpose of IAEA safeguards is maintaining international confidence that states remain compliant with their non-proliferation commitments. If the international community is not confident in the IAEA's safeguards conclusions for states then some countries could react by expanding their own nuclear capabilities in ways that bring them closer to a nuclear weapons development capability. A spiralling of such reactions could threaten long-term peace and security. That confidence in the effectiveness of safeguards is critically important is self-evident but it can also be demonstrated from an examination of INFCIRC/153 and the NPT.

The notion of international confidence is not articulated directly in INFCIRC/153 but there is enough information in the negotiating records of INFCIRC/153 and the NPT to show that this was indeed foundational to the development of IAEA safeguards. For example, the UN General Assembly Resolution 2028 (of 19 November 1965) that initiated NPT negotiations included a set of main principles of relevance here.[6] The first principle was that 'the treaty should be void of any loop-holes that might permit nuclear or non-nuclear Powers to proliferate, directly or indirectly, nuclear weapons in any form'. The fourth principle was that 'there should be acceptable and workable provisions to ensure the effectiveness of the Treaty'.

These two foundational principles speak to the importance of confidence in the system, and this was emphasised further during the NPT negotiations that followed over the following few years. For example, the US Co-Chair of the Eighteen-Nation Committee on Disarmament (ENDC) negotiating the NPT introduced three principles specifically for nuclear safeguards that guided the joint US–Soviet drafting of the NPT's Article III on safeguards.[7] The first of these guiding principles stated that 'there should be safeguards of such a nature that all parties can have confidence in their effectiveness'—again demonstrating even more clearly the importance of confidence in IAEA safeguards in the minds of the negotiators. This also arose frequently in the negotiations of INFCIRC/153 that followed between 1970 and 1971 (involving around 50 states spanning some 82 meetings of what was called Committee 22). Several delegations espoused a 'climate of confidence' in opening statements that helped frame how the negotiations would proceed, and one even stated that the 'cardinal objective was to create an atmosphere of confidence among the parties'.[8]

Essential components of IAEA safeguards

What is required to provide and maintain international confidence in the IAEA's conclusions about the compliance of states with non-proliferation commitments? This paper proposes that confidence is underpinned by six aspects of safeguards implementation: the coverage of safeguards; the independence of the IAEA's findings; appropriate in-field access by the IAEA; adequate tools for assessing compliance; cooperation between the State and the IAEA; and non-discrimination in how the IAEA applies safeguards.

Coverage of IAEA safeguards

The coverage of IAEA safeguards relates to what nuclear materials and activities in a state are subject to IAEA verification. In this respect the overarching obligation is described very early in INFCIRC/153 (paragraph two) as 'the Agency's right and obligation to ensure that safeguards will be applied . . . on *all* source or special fissionable material in all peaceful nuclear activities within the territory of the State . . . for the exclusive purpose of verifying that such material is not diverted to nuclear weapons'.[9] Paragraph one of INFCIRC/153 makes it clear that the state's undertaking is likewise to 'accept safeguards . . . on all source or special fissionable material in all peaceful nuclear activities within its territory, under its jurisdiction or carried out under its control anywhere'.

These paragraphs in INFCIRC/153 reinforce the overarching NPT obligation on non-nuclear-weapon state parties to 'accept safeguards . . . for the exclusive purpose of verification of the fulfilment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses'. Clearly the IAEA's obligation (and in fact right) is to concern itself with both declared *and the possibility of undeclared* nuclear materials and activities. This is also apparent in the negotiating record of INFCIRC/153,[10] was reaffirmed in decisions by the Board of Governors in the 1990s,[11] and has been reaffirmed in decisions of NPT review conferences in 1995, 2000 and 2010.[12]

With the coverage of safeguards in mind the IAEA Secretariat has articulated a set of three generic objectives for verification activities:[13]

1. To detect any undeclared nuclear material or activities in the state as a whole;
2. To detect any undeclared production or processing of nuclear material in declared facilities; and
3. To detect any diversion of declared nuclear material in declared facilities

These objectives correspond to the three general scenarios for the acquisition of nuclear weapons or explosive devices: the use of clandestine nuclear material or facilities; the misuse of declared facilities; and the diversion of declared material.

The coverage is important to the State-level concept as its methodologies and processes are designed to cover generic objectives related to verifying declared nuclear material and activities and to detecting any undeclared nuclear material and activities.

Independence

Arguably the most important requirement for confidence in the IAEA's safeguards findings is that it reaches independent conclusions, and this point certainly featured in the negotiations of INFCIRC/153. For example, the US submission to the negotiations stated that the 'guiding principle of all nuclear safeguards systems is that there must be adequate independent verification that material is not diverted.'[14] Significantly, the underlined emphasis in this quote does in fact appear in the original. The US Ambassador underlined 'independent verification' to emphasise this requirement.[15]

At the start of the negotiations the IAEA Director General tabled a report outlining the secretariat's views on how the agreement should meet NPT requirements. The report began with an outline of four elements essential for any safeguards system, covering knowledge of facilities, record keeping, providing reports, and independent verification.[16]

An example that illustrates the importance of independent verification to the drafters of INFCIRC/153 is the negotiations of paragraph seven, which describes how the secretariat might make use of national systems of accounting for and control of nuclear material to augment its inspection activities. Some proposals during the negotiations were considered to place too much emphasis on the role of states' national findings. There was lengthy negotiation on this point, resulting in a paragraph carefully crafted to ensure that the secretariat's use of state findings preserved the independence of its measurements and observations.[17] This example still has relevance today in the debate over the State-level concept in the context of the secretariat's independence to choose what tools and prioritisations it applies.

Cooperation

Effective and efficient safeguards implementation would not be possible without cooperation between states and the IAEA Secretariat (and vice versa). This principle is given prominence in INFCIRC/153 where one of the early paragraphs (paragraph three) states that 'the Agency and the State shall co-operate to facilitate the implementation of [safeguards]'. It is significant that there was essentially no debate during the negotiations on this paragraph.

The importance of cooperation has long been recognised, and was in fact highlighted in the IAEA's early guidance for states on safeguards implementation.[18] The foreword to that guide stated that 'the following factors are considered of primary importance: cooperation between the Agency, the State and the facility operator in implementing safeguards'. This has also been stressed in more recent guidance documents.[19]

As will be discussed below, one of the state-specific factors used under the State-level concept is the nature and scope of cooperation between the state and the agency.

Non-discrimination in safeguards implementation

A recurring theme in the debate over the State-level concept is the concern expressed by some states that its application could be subjective and discriminatory. It is important that safeguards are implemented in an objective non-discriminatory manner. This does not imply, however, identical IAEA inspection activities in all states. Differentiation without discrimination can be achieved by adopting a uniform process (based on objective factors common to all states) for determining inspection activities, their frequency and intensity, and evaluation approaches.

During the negotiations of INFCIRC/153 non-discrimination and uniformity in the application of safeguards did feature, but so too did the importance of flexibility in the IAEA's methodologies.[20] Of the some 40 states that made statements or submissions setting out their views on the ensuing negotiations, 13 stressed uniformity or non-discrimination in the application of safeguards, and nine stressed flexibility, adaptability or the importance of allowing safeguards to evolve (with some states making both points).[21] However, while the issue of non-discrimination was raised in negotiations, it was not manifested in the final text of INFCIRC/153. Paragraphs four to six set various general, higher-level principles and restraints on how the IAEA applies safeguards but make no reference to uniformity or non-discrimination. On the other hand there are provisions in INFCIRC/153 (for example paragraphs 7, 47, 81) that build in flexibility and differentiation in how safeguards can apply in different states—even those with similar nuclear fuel cycles.

It is clearly important to states that all of them are subject to consistent methodologies and that in-field verification activities are consistent with relevant legal arrangements. The Director General has provided such assurances with respect to the State-level concept.[22] It is important to note that this is not a new assurance. When State-level approaches were first explained in some detail in the Safeguards Implementation Report of 2004 (GOV/2005/32), it was stated that 'State-level approaches are developed on a non-discriminatory basis using safeguards verification objectives which are common to all the states'.

Access and tools

Drawing independent conclusions is one thing, but it requires the necessary access and tools to do so; and these cannot be so constrained or inflexible as to render inspection efforts ineffective. In this regard, INFCIRC/153 has some built-in flexibility on the access available to IAEA inspectors (both in terms of locations and frequency) and accommodates modifying access through improvements in technological tools.

Taking first the question of tools, INFCIRC/153 mentions certain types (such as containment and surveillance) but also contemplates adjustments to methodologies should technologies change. For example, paragraph 6 requires the IAEA to take 'full account of technological developments in the field of safeguards', and paragraph 47 allows the IAEA to re-examine the design information of facilities in light of 'developments in safeguards technology'. There are abundant examples of how the adoption of new technologies has improved the implementation of safeguards, such as remote monitoring systems, improved tamper-indicating seals, higher precision mass spectrometers for environmental sample analysis, satellite imagery, and ground-penetrating radar.

Turning next to frequency of access, this was the subject of some debate during the negotiations of INFCIRC/153. The model for determining inspection frequency at that time was a set of inspection frequency tables in the facility-specific safeguards agreement, INFCIRC/66/Rev.2. Several states pointed out that given the NPT required all nuclear material across all facilities to be safeguarded, a different model should be adopted to ensure the IAEA Secretariat could introduce rationalisations and simplifications to its procedures across facilities.[23] The compromise was a series of paragraphs (78 to 82) that set maximum routine inspection frequencies and intensities on the basis of nuclear material quantities and types, but allows the secretariat to reduce these through consideration of a series of state-specific factors outlined in paragraph 81.

Background: safeguards developments since the 1990s

This section provides some basic background on changes in IAEA safeguards since the 1990s, to put the development of the State-level concept into context.

1990s—the development of strengthened safeguards

Notwithstanding the IAEA's right to concern itself with possible undeclared nuclear material and activities, typical safeguards practice through to the 1990s was to focus only on verifying that declared nuclear material was accounted for. The watershed event that changed this situation was the discovery in 1991 of Iraq's clandestine nuclear weapon program. Some aspects of this program had been carried out in buildings on the same site where IAEA inspectors had been inspecting other buildings; demonstrating the shortcomings of verifying only locations with declared nuclear material and activities. This event focussed the world's attention on strengthening safeguards. There were several expert studies and projects in the 1990s looking at this, and the IAEA conducted an extensive study (known as Programme 93+2) that assessed mechanisms for strengthening the effectiveness and improving the efficiency of safeguards.

The strengthened safeguards regime that resulted from this process has two components: decisions of the Board of Governors reaffirming the value of some under-utilised tools and authorities under the existing legal framework of INFCIRC/153; and the expansion of the IAEA's verification toolkit through the model Additional Protocol.[24] The access rights and reporting obligations outlined in the Additional Protocol strengthen the secretariat's hand in verifying the absence of undeclared nuclear material and activities. Importantly, as noted above, the Additional Protocol did not introduce a new legal mandate in relation to undeclared nuclear material and activities; this mandate already existed in INFCIRC/153. The Additional Protocol provided additional tools to assist its fulfilment.

2000s—the development of State-level approaches

The strengthening of safeguards also led to a re-evaluation of how best to structure and prioritise the secretariat's in-field activities, as well as its headquarters evaluation and analysis. Traditionally, IAEA safeguards were implemented using quite formalised inspector guidance or later 'safeguards criteria' that prescribed uniform verification activities for each type of nuclear installation. The safeguards criteria were designed around technical objectives to detect diversion or misuse. However, the criteria were used mostly in a process-oriented manner based on the inspection activities themselves. This meant the focus was more on completing specified inspection activities rather than the technical objectives that the activities were designed to address.[25]

This facility-level approach served the purposes of the time. However, as the numbers of facilities and the quantities of nuclear material under safeguards increased, and as it became clear that the risk profile of the nuclear fuel cycle required greater attention to potential undeclared activities, it became apparent that a better, more targeted approach was required. This is where the shift to State-level approaches first came in for a limited number of states, under what are called Integrated Safeguards.[26] Integrated Safeguards apply only to states that have the Additional Protocol in force, and where the secretariat has determined it can draw what is known as the broader conclusion through the Additional Protocol's expanded toolkit.[27] Safeguards measures can then be integrated—meaning that greater efficiency and effectiveness can be achieved by optimising the use of information and tools available under both the Comprehensive Safeguards Agreement and the Additional Protocol. Integrated Safeguards were first implemented in Australia in 2001 and now apply to over 50 states.

2010s—expansion of State-level approaches

The expansion of Integrated Safeguards to more and more states meant more effective and efficient safeguards in more states. However, while considerations relating to the state as a whole were being used, the IAEA Secretariat recognised that further improvements could be made for states with Integrated Safeguards, as well as expanding State-level approaches to all other states (particularly those with a Comprehensive Safeguards Agreement but no Additional Protocol). At the 2010 Safeguards Symposium the then Deputy Director General and head of the Department of Safeguards, Herman Nackaerts, announced the IAEA's plans in this regard and the secretariat's work on this began in earnest.[28] While the term 'State-level concept' had been used in official IAEA documents for some time (such as the Safeguards Implementation Report for 2004 (GOV/2005/32)) it was around 2010 that the term came into wide use among the safeguards community to describe the IAEA's work on expanding and adapting State-level approaches.

Starting in 2012 the State-level concept became the subject of considerable debate among IAEA Member States, with a few raising concerns in IAEA Board of Governors meetings and IAEA General Conferences. The negotiations of the safeguards resolution in the General Conferences of 2012 through to 2015 had lengthy debates on the State-level concept.[29] The issue has revolved primarily around a combination of differing views among states on the scope of the IAEA's mandate to adapt processes and methods, and an incomplete understanding of what the secretariat was trying to achieve. A contributing factor was the secretariat's initial communication approach on the State-level concept. Some states felt they were not sufficiently consulted on this development. Furthermore, as the State-level concept was a work in progress, the details had evolved during its development and hence so did the terminology; which did not assist member states' understanding of the concept.

The secretariat has acknowledged the need for better communication and accepted the request of member states for greater consultation and information on the State-level concept.[30] In response, the IAEA Director General released a report in August 2013: The Conceptualization and Development of Safeguards Implementation at the State Level (GOV/2013/38).[31] There was much debate in the September 2013 IAEA Board of Governors meeting on whether this report provided enough detail on implementation, so the Director General agreed to provide a supplementary document with further clarifications. To ensure all concerns were covered and questions answered, the secretariat held an extensive series of seven technical meetings from January to July 2014 open to all member states, at which it presented in detail the various aspects of the State-level concept and responded to questions. These technical meetings were widely attended by interested member states.

The Supplementary Document to the Report on The Conceptualization and Development of Safeguards Implementation at the State Level (GOV/2014/41) was released in August 2014, and had considerably more detail on the elements of the State-level concept to complement GOV/2013/38.[32] There was still debate on this issue and a strong desire among some states to reinforce assurances that the concept would not introduce additional rights or obligations or modify the interpretations of these. With such assurances made by the Director General during the 2014 Board of Governors meeting the prevailing mood among most member states was one of appreciation of the efforts of the secretariat to explain the State-level concept, and a desire for the secretariat to consult closely with member states (as the Director General has undertaken) as it develops or modifies State-level approaches in each state. Discussions at the 2015 General Conference on this subject centred on expectations of timeframes for periodic update reports by the secretariat on the implementation of State-level approaches. Preparing further reports along the lines of GOV/2013/38 and GOV/2014/41 would be a resource-intensive exercise and besides, only a few State-level approaches had been developed by this stage. As such, the view of most states was that while implementation reports are important, the secretariat should not be subject to any particular timeframes until it has more implementation experience. This is reflected in the paragraphs on reporting and consultations on the State-level concept in the 2015 safeguards resolution.

What is the State-level concept?

Short answer—without jargon terms

The State-level concept is essentially about flexibly focussing the IAEA Secretariat's verification efforts for each state on areas where they are most effective and relevant to technically plausible pathways for acquiring nuclear material for weapons. The determination of the most relevant pathways takes into account technical capabilities across the whole state, rather than just the misuse potential of individual facilities alone. Once this analysis has been completed the secretariat can determine, within the relevant legal arrangements for each state, which in-field activities most effectively target the identified pathways.

Evaluating the compliance of each state with non-proliferation commitments is not just about in-field inspections. It also requires analysis and evaluation in headquarters. In determining the balance of resources across both in-field and headquarters activities the secretariat also takes into account factors such as the correctness and completeness of the state's reports, the capabilities of the state's system to account for and control nuclear material and activities, and its experience in implementing safeguards in that state.

Long answer—with jargon terms

The Director General's report GOV/2014/41 describes the State-level concept as 'the general notion of implementing safeguards in a manner that considers a State's nuclear and nuclear-related activities and capabilities as a whole, within the scope of the safeguards agreement', and a State-level approach as 'a customized approach to implementing safeguards for an individual State. . . . It consists of safeguards objectives for a State as well as applicable safeguards measures, to be implemented by the Agency in the field and at Headquarters, to address those objectives'. The steps that the IAEA Secretariat uses to develop State-level approaches are as follows:

1. It first does an acquisition path analysis of all technically plausible pathways by which the State has the technical capability to acquire nuclear material suitable for use in a nuclear weapon or other explosive device.[33]
2. The technically plausible pathways are prioritised according to safeguards significance and broken up into the steps required, and technical objectives are determined and prioritised for detecting the various steps for each pathway.
3. Safeguards measures for addressing the technical objectives are then identified.

With State-level approaches established, the secretariat can proceed with planning and conducting in-field verification and headquarters evaluation in a way that is optimised to the more technically plausible acquisition pathways for each state. The secretariat also evaluates whether these safeguards measures have achieved the technical objectives for each state and feeds this back into the process to better target further in-field and headquarters work if required.

The process described above also incorporates what are known as state-specific factors. GOV/2014/41 describes these as 'six objective safeguards-relevant factors that are particular to a State which are used by the Secretariat in the development of a State-level safeguards approach and in the planning, conduct and evaluation of safeguards activities for that State.' The six state-specific factors are:

1. The type of safeguards agreement in force for the state and the nature of the safeguards conclusion drawn by the IAEA;
2. The nuclear fuel cycle and related capabilities of the state;
3. The technical capabilities of the state (or regional, if relevant) system of accounting for and control of nuclear material;
4. The ability of the IAEA to implement certain safeguards measures in the state;
5. The nature and scope of the cooperation between the state and the agency in the implementation of safeguards; and
6. The IAEA's experience in implementing safeguards in the state.

Some of these factors primarily inform the acquisition path analysis step and the setting and prioritisation of technical objectives, whereas others inform the secretariat's planning, conduct and evaluation of in-field and headquarters activities.

State-specific factors under the State-level concept

A particular aspect of the State-level concept that has attracted considerable debate is these six state-specific factors. This paper will now examine how state-specific factors are accommodated by, and in some cases explicitly provided for, in INFCIRC/153.

Types of safeguards agreements in force and the nature of safeguards conclusions

The types of reports and declarations the IAEA Secretariat receives from states are determined by the relevant legal framework (such as Comprehensive Safeguards Agreement with or without an Additional Protocol). The secretariat's inspection activities must also be consistent with the relevant legal mandate. Clearly, therefore, the types of safeguards agreements in force will determine how the secretariat conducts in-field activities and will determine what data it receives from states to use in evaluations in headquarters.

Regarding the safeguards conclusions aspect of this state-specific factor, if there is a problem with reaching safeguards conclusions about a state then it is self-evident that this is a factor the secretariat should take into account when planning, conducting and evaluating in-field and headquarters activities. The alternative situation—where the secretariat considers neither indications of non-compliance nor known issues—would not engender confidence in the secretariat's conclusions. But the relevance of safeguards conclusions to how the secretariat conducts its in-field and headquarters activities does not just apply to non-compliance concerns. If the broader conclusion has been drawn then this allows for a better integration of verification tools, so clearly this influences safeguards activities for the state as well.

Nuclear fuel cycle and related capabilities of the state

The nuclear facilities and nuclear-related capabilities in a state are essential components of any analysis of technically plausible pathways for acquiring nuclear material for weapons, and therefore a factor in determining the secretariat's in-field and headquarters activities. The notion of considering a state's overall nuclear fuel cycle capabilities in determining inspection effort has a long history. The IAEA safeguards system developed pre-NPT for application to individual reactors (as described by INFCIRC/26 (1961) and INFCIRC/66 (1965)) both included provisions whereby the actual frequency of inspection of a reactor could take into account whether the state possessed irradiated-fuel reprocessing facilities.[34]

Unsurprisingly, INFCIRC/153 has explicit provisions for this state-specific factor. Paragraph 81 lists several 'criteria to be used for determining the actual number, intensity, duration, timing and mode of routine inspections of any facility'. This list includes: 'characteristics of the State's nuclear fuel cycle, in particular, the number and types of facilities containing nuclear material subject to safeguards, the characteristics of such facilities relevant to safeguards'; 'the extent to which the design of such facilities facilitates verification of the flow and inventory of nuclear material'; and 'the extent to which information from different material balance areas can be correlated'.

Factors about a state's nuclear fuel cycle have therefore long been established as part of the secretariat's decision-making process for setting the frequency and intensity of inspections.

Technical capabilities of system of accounting for and control of nuclear material

This state-specific factor is also explicit in INFCIRC/153. Paragraph seven states that the IAEA's verification 'shall take due account of the technical effectiveness of the State's system'.[35] Similarly, another criterion under paragraph 81 for determining the number, intensity, duration, timing and mode of routine inspections of any facility is 'the effectiveness of the State's accounting and control system, including the extent to which the operators of facilities are functionally independent of the State's accounting and control system'. Making use of the state's technical capabilities can lead to efficiencies through, for example, making use of national inspector data, sharing of equipment or doing joint inspections. This factor therefore influences how the IAEA conducts in-field verification activities or headquarters analysis.

Ability of the IAEA to implement certain safeguards measures in the state

This state-specific factor relates to the secretariat's ability to implement the types of technical or inspection measures that can improve the effectiveness or efficiency of safeguards. Considering inspections first, an example is unannounced or short notice inspections. The unpredictability of this option allows the secretariat to perform a smaller number of scheduled inspections, which can lead to an overall reduction in effort by the secretariat and the state. Unannounced inspections are provided for in paragraph 84 of INFCIRC/153 and are a standard part of IAEA inspection activities in many states.[36]

Considering technical measures, one example that can reduce inspection effort is remote monitoring—the transmission of verification data from unattended systems via communication networks to IAEA headquarters for review and evaluation. This has been in use for many years in some states. Remote monitoring is not mentioned directly in INFCIRC/153, but paragraph six does provide that 'the Agency shall take full account of technological developments in the field of safeguards'. Clearly, if a technical measure adds to the effectiveness or efficiency of safeguards implementation then the ability or inability of the secretariat to perform this would inform the planning and conduct of verification activities. Importantly, if a technical measure cannot be implemented this does not imply a judgement of compliance; it is rather a fact that needs to be taken into account when designing State-level approaches appropriate to the state.

Nature/scope of cooperation between the state and the agency

As noted above, an early paragraph in INFCIRC/153 (paragraph three) states that the IAEA and the state should cooperate to facilitate the implementation of safeguards. It is clear that cooperation is fundamental to safeguards, and the absence of cooperation by a State could hinder the secretariat's ability to draw safeguards conclusions. The link between the cooperation of states and safeguards conclusions is not new. The secretariat's Safeguards Implementation Reports as far back as the late 1970s and early 1980s routinely explained that the 'confidence level' or 'level of assurance' in the secretariat's findings on a state depend on, *inter alia*, 'co-operation of the State and of the facility operators'.

The notion of cooperation should be clear in order to establish a consistent framework across all states for objective evaluation. GOV/2013/38 and GOV/2014/41 explain that this state-specific factor relates to aspects such as the timeliness, correctness and completeness of declarations and reports provided by the state, the state's responsiveness in addressing anomalies, questions or inconsistencies, and facilitation of inspector access.[37]

All other things being equal, if states provide complete, correct and timely reports, the secretariat's in-field and headquarters verification activities require less effort. There is nothing new about recognising the importance of these aspects of cooperation. For example, the secretariat's note on the required content of INFCIRC/153 that framed the start of negotiations on this document in 1970 included these aspects of cooperation.[38] In describing the considerations for inspections, this note stated that 'the Agency, in determining the number, intensity and duration of inspections, would take account of the promptness, accuracy and consistency of reports'. These concepts are reflected in paragraph 81 of INFCIRC/153 as described above.

The timely resolution of anomalies is also a very important aspect of cooperation. The IAEA Safeguards Glossary defines an anomaly as an 'unusual observable condition which might result from diversion of nuclear material or misuse of safeguarded items, or which frustrates or restricts the ability of the IAEA to draw the conclusion that diversion or misuse has not occurred.' Examples of anomalies include: denial or restriction of inspector access; unreported safeguards-significant changes to facility design or operating conditions; a discrepancy involving more than a significant quantity of nuclear material; and evidence of tampering with IAEA equipment. Clearly cooperation on resolving anomalies can be critical to IAEA safeguards conclusions, so this is a factor that should inform the secretariat's planning, conduct and evaluation of in-field and headquarters activities. Likewise, cooperating in facilitating IAEA inspector access is also very important. The alternative scenario—if the secretariat were not to take into account anomalies or issues with inspector access—would not engender confidence in the IAEA's conclusions.

IAEA's experience in implementing safeguards in the state

The concept of adapting safeguards measures as experience is gained by the IAEA also has a long history. The original safeguards agreements, The Agency's Safeguards (INFCIRC/26, 1961) and The Agency's Safeguards System (INFCIRC/66, 1965) both had provisions allowing for the safeguards principles and procedures to be subject to review in the light of experience gained by the IAEA or on the basis of technological developments.[39]

INFCIRC/153 likewise has provisions whereby procedures can be adapted on the basis of the IAEA's experience. Paragraph six sets down the general principle that the IAEA shall 'take full account of technological developments in the field of safeguards'. Paragraph 47 allows for the IAEA's experiences to be considered for modifications of the structures and procedures that underpin how safeguards are applied in particular facilities. For example, safeguards approaches for enrichment plants have been updated significantly over the years.

This state-specific factor could be influenced by agency experience of: the reliability of external power sources and their effect on equipment; the operators willingness to allow the application of IAEA seals to maintain continuity of knowledge on some material; the State's approach to resolving anomalies or questions and inconsistencies; and local security conditions that can impede inspector access to facilities.

Concluding remarks

This paper has explained in some detail the provisions in INFCIRC/153 that support specific aspects of the State-level concept for IAEA safeguards implementation. Details are important, but it is also important in any debate over how the IAEA implements safeguards not to lose sight of the fundamental objective: these safeguards should engender confidence among the international community of the compliance of states with their non-proliferation commitments. This paper has shown that this was forefront in the minds of the negotiators of INFCIRC/153, and to achieve this INFCIRC/153 was drafted in a way that provides built-in adaptability for the IAEA Secretariat to evolve methodologies as it learns how to apply safeguards more effectively. This includes the process of varying the scope, frequency and intensity of verification activities on the basis of performance-related factors. There is a perception apparent in some criticisms raised in IAEA fora that the processes underpinning the State-level concept represent something fundamentally new. To the contrary, the State-level concept is about making more effective use of the adaptability already provided for in INFCIRC/153.

Fundamentally, the State-level concept is about applying a whole-of-system evaluation of safeguards-relevant information about a state, in order to direct verification activities flexibly to where these are most effective and relevant to the technically plausible pathways for acquiring nuclear material for weapons. Better directing efforts in this way should also enable more efficient use of the secretariat's finite resources, which helps maintain another obligation in INFCIRC/153, namely that the IAEA '[makes] every effort to ensure optimum cost effectiveness' (paragraph six) and makes 'the optimum and most economical use of available inspection resources [for routine inspections]' (paragraph 78).

As this paper has outlined, the State-level concept is fully consistent with INFCIRC/153, and so does not require approval of the Board of Governors. The way the Board of Governors considered Integrated Safeguards helps put this into context. When Integrated Safeguards were developed in the early 2000s, the Director General issued a report explaining how this would be done.[40] This report recommended that the Board of Governors take note of the conceptual framework of Integrated Safeguards, that it take note that the Director General was proceeding with its implementation, and that it request the Director General proceed further with such implementation. The report did not seek the approval of the Board of Governors. When the Board of Governors considered this report, it took the decisions as recommended by the Director General.

Subjecting the methodologies and processes that underpin the State-level concept to approval of the Board of Governors would set a fraught precedent of micromanaging the secretariat's work. Micromanaging operational matters would risk constraining the secretariat's ability to apply safeguards in the way it has determined, within its technical competencies and mandate, is most effective. Such a situation would not be conducive to the fundamental and foundational principle of IAEA safeguards, that is, maintaining international confidence in the IAEA's findings on the compliance of states with non-proliferation commitments. There are many details in how the State-level concept is implemented, so it is understandable for states to seek explanations to assure themselves its implementation is consistent with the relevant safeguards agreements. In this regard, the Director General's assurances that the State-level concept will not introduce any additional rights or obligations or modify interpretations are very important and will hopefully assuage any remaining concerns.[41]

The views in this paper are those of the author, not necessarily those of the Australian government.

Endnotes

1 The State-level concept is the overall conceptual framework, whereas a State-level approach is a document that describes the approach to applying safeguards in a particular State when developed using the State-level concept.

2 See: 'The Conceptualization and Development of Safeguards Implementation at the State Level', GOV/2013/38, International Atomic Energy Agency, August 2013; 'Supplementary Document to the Report on The Conceptualization and Development of Safeguards Implementation at the State Level', GOV/2014/41, International Atomic Energy Agency, August 2014.

3 These assurances can be found in: 'Record of the 1383rd Meeting', GOV/OR.1383, Board of Governors, International Atomic Energy Agency, September 2014; 'Strengthening the Effectiveness and Improving the Efficiency of Agency Safeguards', GC(58)/RES/14, General Conference, International Atomic Energy Agency, September 2014; and repeated in 'Strengthening the Effectiveness and Improving the Efficiency

of Agency Safeguards', GC(59)/RES/13, General Conference, International Atomic Energy Agency, September 2015.

4 For the remainder of this paper, the shorthand INFCIRC/153 will be used.

5 For example, see 'Review of the Negotiating History of the IAEA Safeguards Document INFICIRC/153', US Arms Control and Disarmament Agency, 30 June 1984. Available at: cgs.pnnl.gov/fois/documents.stm

6 UN General Assembly Resolution 2028 is available at: www.un.org/documents/ga/res/20/ares20.htm

7 'First Verbatim Record of the 357th Meeting of the Conference of the Eighteen-Nation Committee on Disarmament', ENDC/PV.357, United Nations, January 1968. Para. 55.

8 Statements by states to Committee 22 can be found in official IAEA documents GOV/COM.22/2, GOV/COM.22/2/Add.1 through to GOV/COM.22/2/Add.4, and in records GOV/COM.22/OR.1 through to GOV/COM.22/OR.5.

9 Emphasis added.

10 For example, one State proposed that the IAEA's safeguarding and inspection functions should 'be concerned solely with the material reported upon by the State concerned to the Agency in the initial and subsequent reports and material derived therefrom' (see GOV/COM.22/8, official document of Committee 22). This view was rejected by the other negotiators as it was not consistent with the NPT, reinforcing further that INFCIRC/153 is not limited to declared nuclear material. For a detailed analysis of how INFCIRC/153 provides a mandate for undeclared nuclear material and activities, see: 'Review of the Negotiating History of the IAEA Safeguards Document INFICIRC/153' (1984). pp.33-43.

11 For example, see: 'Safeguards: Draft Resolution submitted by Egypt, Morocco, Nigeria and Tunisia on Behalf of the Africa Group', GOV/2547/Rev.1, Board of Governors, International Atomic Energy Agency, September 1991; Resolution GOV/2636, Board of Governors, International Atomic Energy Agency, February 1993; and Official Record GOV/OR.864, Board of Governors, International Atomic Energy Agency March 1995.

12 For example, the 2010 NPT Review Conference reaffirmed 'that the implementation of comprehensive safeguards agreements . . . should be designed to provide for verification by IAEA of the correctness and completeness of a State's declaration, so that there is a credible assurance of the non-diversion of nuclear material from declared activities and of the absence of undeclared nuclear material and activities.' See '2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons: Final Document', NPT/CONF/2010/50 (Vol.1), United Nations, June 2010. The 2015 Review Conference did not conclude a final consensus document but the final document presented to the plenary on the last day of the conference included this same standard statement.

13 These were first described in the IAEA Safeguards Implementation Report for 2005 (GOV/2006/31).

14 See: 'First Verbatim Record of the 357th Meeting of the Conference of the Eighteen-Nation Committee on Disarmament' (1968). Para. 55. Emphasis not added.

15 Myron Kratzer, principal US negotiator in the development of INFCIRC/153, interviewed in 'Retrospective of INFCIRCs 153 and 540 with Myron Kratzer, Rich Hooper, and Ambassador Norm Wulf', Santa Fe, October 2005. Available at http://cgs.pnnl.gov/fois/default.stm

16 The report is reflected in GOV/COM.22/3, official document of Committee 22 of the IAEA.

17 The debate on paragraph seven of INFCIRC/153 can be found in the following official records of Committee 22: GOV/COM.22/OR.8 and GOV/COM.22/OR.10. A detailed summary and analysis of this debate can be found in 'Review of the Negotiating History of the IAEA Safeguards Document INFICIRC/153' (1984). pp. 33–43.

18 'Guidelines for States' Systems of Accounting and Control of Nuclear Materials', IAEA/SG/INF/2, International Atomic Energy Agency, December 1980.

19 'Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols', *IAEA Service Series*, No. 21, International Atomic Energy Agency, March 2012; 'Fundamentals and Good

Practices of Safeguards Regulatory Authorities, a paper by the Asia-Pacific Safeguards Network (APSN)', Asia-Pacific Safeguards Network, October 2012.

20 'Review of the Negotiating History of the IAEA Safeguards Document INFICIRC/153' (1984).

21 See statements from Committee 22 documents, including GOV/COM.22/2, GOV/COM.22/2/Add.1 through to GOV/COM.22/2/Add.4, and in records GOV/COM.22/OR.1 through to GOV/COM.22/OR.5.

22 See: 'The Conceptualization and Development of Safeguards Implementation at the State Level', GOV/2013/38, International Atomic Energy Agency, August 2013; and 'Supplementary Document to the Report on The Conceptualization and Development of Safeguards Implementation at the State Level', GOV/2014/41, International Atomic Energy Agency, August 2014.

23 See the views of member states conveyed at Committee 22 meetings (reflected in GOV/COM.22/2 and GOV/COM/2/Add.1).

24 'Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards', INFCIRC/540(corrected), International Atomic Energy Agency, September 1997. From hereon referred to as INFCIRC/540.

25 For more details on the safeguards criteria see: 'Supplementary Document to the Report on The Conceptualization and Development of Safeguards Implementation at the State Level' (2014), Section C.4; and J. Larrimore, 'IAEA Safeguards Criteria', *Journal of Nuclear Material Management*, Volume XXI, No. III, May 1993.

26 The framework for Integrated Safeguards is described in: 'The Conceptual Framework for Integrated Safeguards', GOV/2002/88, Board of Governors, International Atomic Energy Agency, February 2002. This outlined how State-level approaches and state-specific factors would be incorporated under Integrated Safeguards. For a contemporaneous overview of Integrated Safeguards at that time see 'Background on IAEA Board of Governors' Approval of Framework for Integrated Safeguards', IAEA News Center, International Atomic Energy Agency, March 2002. Available at: www.iaea.org/newscenter/news/2002/sgarticle_02.shtml

27 This broader conclusion expresses the secretariat's highest confidence in a state, namely that all nuclear material remains in peaceful activities. This conclusion is drawn on the basis that the secretariat could find no indications of the diversion of declared nuclear material, or any indications of undeclared nuclear material or activities.

28 Herman Nackaerts, 'Statement at Symposium on International Safeguards: Preparing for Future Verification Challenges', IAEA News Center, International Atomic Energy Agency, November 2010. Available at: www.iaea.org/newscenter/statements/ddgs/2010/nackaerts011110.html

29 See for example debates in the transcripts for the plenary meeting and committee of the whole at the 2012, 2013 and 2014 IAEA General Conferences (www.iaea.org/About/Policy/GC/index.html). Some analysis on these events can be found in: Laura Rockwood, 'The IAEA's State-Level Concept and the Law of Unintended Consequences', *Arms Control Today*, Vol. 44, September 2014; Mark Hibbs, 'The Plan for IAEA Safeguards', Carnegie Endowment for International Peace, November 2012; and Mark Hibbs, 'IAEA Safeguards Development and Russia's National Interest', Carnegie Endowment for International Peace, November 2014.

30 See for example the keynote address to the Institute of Nuclear Material Management annual meeting in 2014: Taro Varjoranta, 'Further Optimisation of IAEA Safeguards is Essential', Institute of Nuclear Material Management annual meeting, July 2014. Available at: www.iaea.org/safeguards/DDG-Corner/dg-statements-repository/index.html

31 'The Conceptualization and Development of Safeguards Implementation at the State Level' (2013)

32 See 'Supplementary Document to the Report on The Conceptualization and Development of Safeguards Implementation at the State Level' (2014) and *Ibid*., respectively.

33 The IAEA Safeguards Glossary of 2001 describes this as 'the analysis of all plausible acquisition paths or acquisition strategies for a State to acquire nuclear material usable for the manufacture of a nuclear

explosive device'. Acquisition/diversion path analysis has a long history in IAEA safeguards. For example the Safeguards Implementation Reports for 1978 and 1979 describe the development and use of diversion path analyses for some facilities. This was also used in the development of the Physical Model of the nuclear fuel cycle under the strengthened safeguards program in the mid-1990s as a technical tool for enhanced information analysis (see Z. Liu and S. Morsey, 'Development of the Physical Model', *Symposium on International Safeguards Verification and Nuclear Material Security*, IAEA-SM-367/13/07, International Atomic Energy Agency, November 2001.

34 Paragraph 65 of INFCIRC/26 and paragraph 58 of INFCIRC/66/Rev.2—both of which applied to inspection frequency at reactors.

35 As noted in sub-section 'Independence' above, paragraph seven was carefully crafted to ensure the IAEA's use of the findings of state systems preserved the independence of the IAEA's measurements and observations.

36 Paragraph 84 of INFCIRC/153 states that 'the Agency may carry out without advance notification a portion of routine inspections'.

37 See 'The Conceptualization and Development of Safeguards Implementation at the State Level' (2013) and 'Supplementary Document to the Report on The Conceptualization and Development of Safeguards Implementation at the State Level' (2014), respectively

38 See GOV/COM.22/3; official document from Committee 22.

39 See paragraph five of INFCIRC/26 and paragraph eight of INFCIRC/66/Rev.2.

40 See 'The Conceptual Framework for Integrated Safeguards' (2002).

41 See: 'The Conceptualization and Development of Safeguards Implementation at the State Level' (2013) and 'Supplementary Document to the Report on The Conceptualization and Development of Safeguards Implementation at the State Level' (2014).

CHAPTER 4

Organisational culture for safety, security and safeguards in new nuclear power countries

Donald Kovacic

Developing a nuclear power programme is a large undertaking requiring careful planning, preparation, and a major investment in a sustainable infrastructure. This infrastructure must provide legal, governmental, regulatory, financial, technological, human and industrial support to ensure that nuclear power plants are designed and operated in a safe and secure manner, and that nuclear materials are used exclusively for peaceful purposes. For countries interested in incorporating nuclear power into their domestic energy mix, the development and implementation of an appropriate infrastructure is essential.

The International Atomic Energy Agency (IAEA) advises that such countries follow the 'Milestones' approach.[1] This guidance describes the issues and phases involved in building the capacity for planning, constructing and operating their first nuclear power plant. Such capacities are needed across governmental, industrial, technical and educational institutions. This comprehensive approach includes the issues of nuclear safety, security and safeguards—sometimes referred to as the '3S' approach. Security and safeguards are part of the nuclear non-proliferation regime whose purpose is to prevent the spread of nuclear weapons.

The focal point of a nuclear power programme is the operator of a nuclear facility. As such, the operator must comply with a number of national and international requirements in the areas of nuclear safety, security and safeguards. These requirements should be reflected in national laws and in regulations (including those from nuclear regulatory bodies, security organisations and other institutions). To be able to comply adequately with their commitments, operators of nuclear facilities must develop an organisational culture that will embrace these three fundamental requirements.

The concept of nuclear safety culture is well established, and there is much guidance available. In contrast, the concept of nuclear security culture is currently being developed, primarily through the IAEA and the World Institute of Nuclear Security.[2] However, at present there is no widely accepted understanding of what is meant by a 'safeguards' or 'non-proliferation' culture. Therefore, to understand how non-proliferation fits within a nuclear power programme, this chapter focuses on practical considerations and realities that exist at nuclear facilities, and the challenges that organisations face in their day-to-day operations to operate safely and to meet their non-proliferation commitments. It also explores how countries with established nuclear power programmes can collaborate with nuclear newcomer countries to support the development of infrastructure that allows them to benefit from the peaceful applications of nuclear technology by seeking the most effective and efficient way of implementing safety, security, and safeguards requirements. It is in the interest of all nations that countries developing nuclear power programmes do so in a way that meets international standards and obligations.

This chapter begins by outlining existing international norms and standards for developing the infrastructure to support new nuclear power programmes. It then discusses the role of organisational culture, and how it can support the safe, secure and peaceful application of nuclear power. The chapter identifies effective and efficient strategies for implementing safety, security and safeguards in nuclear operations and also the challenges that can arise. It concludes by proposing potential areas for future collaboration between countries to support non-proliferation culture.

Existing international norms and standards for developing infrastructure to support new nuclear power programmes

After the Second World War, the world seemed to be headed toward a future where many countries possessed nuclear armaments that could potentially be used in a new kind of war—a nuclear war. Some statesmen and diplomats were concerned with the implications of these new weapons and began proposing ideas on how to avoid widespread nuclear war. One of these early ideas was the Baruch Plan, which was presented to the United Nations Atomic Energy Commission (UNAEC) in 1946.

The UNAEC was established by the then newly created United Nations to

> make specific proposals: (a) for extending between all nations the exchange of basic scientific information for peaceful ends; (b) for control of atomic energy to the extent necessary to ensure its use only for peaceful purposes; (c) for the elimination from national armaments of atomic weapons and of all other major weapons adaptable to mass destruction; (d) for effective safeguards by way of inspection and other means to protect complying States against the hazards of violations and evasions.[3]

On 14 June 1946, before a session of the UNAEC, US representative Bernard Baruch, presented a proposal for the creation of an international atomic development authority.[4] Although this plan was ultimately rejected because of tensions between the United

States and the Soviet Union, portions of the plan sound similar to the mandate of the IAEA, which was to be established in 1957, and then later the Nuclear Non-proliferation Treaty (NPT) in 1970.

The IAEA and the NPT collaboratively set up a framework that has the following main pillars:

- Assurances against the proliferation of nuclear weapons (that is, non-proliferation);
- The promise for eventual nuclear weapons disarmament;
- The right for all countries to enjoy the benefits of peaceful uses of nuclear technology.

The NPT prohibits the nuclear weapons states (NWSs)[5] from transferring weapons material and technology to non-nuclear weapons states (NNWSs). It also prohibits NNWSs from receiving such materials, and also requires them to negotiate comprehensive safeguards agreements (CSAs) with the IAEA. CSAs form the legal basis for the IAEA to inspect and verify that NNWSs are in fact complying with their obligations under the NPT. In return, the NNWSs have a right to benefit from the peaceful uses of nuclear energy. That is why the NPT is sometimes called the 'Grand Bargain.' The NNWSs agree never to acquire nuclear weapons, and in exchange, the NWSs agree to share the benefits of peaceful nuclear technology and to pursue nuclear disarmament aimed at the ultimate elimination of their nuclear arsenals.

The international safeguards regime and verification by the IAEA form the historical foundation of nuclear non-proliferation, but they are not the only components. Security at nuclear facilities is another fundamental component necessary to ensure that applications of nuclear technology are only used for peaceful purposes. How these two elements of safeguards and security are implemented by countries *and integrated with nuclear safety,* as part of a sustainable nuclear power programme is the subject of the rest of this chapter. This will, of course, be put within the context of global nuclear non-proliferation and how a level of transparency can be achieved so that all nations benefit from the 'Grand Bargain.'

Nuclear power is one of the chief peaceful uses of nuclear energy and the one that was primarily envisioned during the creation of the IAEA and the drafting of the NPT. Currently, there are many countries that would like to include nuclear power as part of their energy mix.[6] Availability of electricity is a principal factor in raising the standard of living for a society. Abundant and reliable power fuels economic growth and industrial competitiveness. Nuclear energy can provide a secure supply of low carbon electricity for this purpose. Of course, there are a number of factors that must be considered when determining whether or not nuclear power can be competitive for a given country's circumstances. This is the reason why sound economic and planning studies must be undertaken before such a decision can be made. Many countries have done this and have determined that nuclear power can be of benefit to them. Although the accident at the Fukushima Daiichi Nuclear Plant in 2011 had a significant impact on this cost-benefit analysis for many countries, a number of them are still moving forward with their plans for nuclear power programmes, and they are being careful to incorporate lessons learned from the accident. In his address during the Energy Market Authority Distinguished Speaker Programme in Singapore in January 2015, the Director General of the IAEA, Mr. Yukiyama Amano stated that:

> . . . the basic situation concerning nuclear power has actually not changed that much since . . . 2010. Many new countries still plan to introduce nuclear power in the coming decades. Global use of nuclear power will grow, although growth rates are likely to be slower than estimated before the accident . . .[7]

Once a country makes a 'knowledgeable commitment' to build a nuclear power plant, it must begin considering how to operate that facility safely and securely. As outlined at the beginning of this chapter, the IAEA has been developing a series of guideline documents aimed at helping countries identify what they must do to effectively operate a nuclear power plant and how they might do it. One of these main documents describes the milestones for developing the infrastructure to support a national nuclear power programme: 1) ready to make a knowledgeable commitment to a nuclear power programme; 2) ready to invite bids/negotiate a contract for the first nuclear power plant, and 3) ready to commission and operate the first nuclear power plant. Furthermore, it describes 19 separate issues that must be considered during the three milestones. Nuclear safety, security, and safeguards are only part of this process. If issues such as economic sustainability, financing and public acceptance, etc., do not allow nuclear power to be implemented, then a nuclear programme will not be possible—or at least not until the conditions change.

Once the underlying economic, political and social conditions allow a nuclear programme to move forward, a country must begin preparing the underlying infrastructure necessary for such a programme to be successful. Nuclear safety, security and safeguards are the three parts of this infrastructure where one nation's nuclear programme can have a direct impact on all other nations, and so must be given special consideration. Additionally, it is a fundamental tenant of sustainability that these three areas are well integrated with all the other aspects of a nuclear programme. In other words, a sustainable nuclear power programme requires that safety, security and safeguards are adequately considered as part of the nation's nuclear infrastructure. This is the fundamental premise of this chapter.

For a nuclear power programme, there are three basic levels, which must be considered: the legal basis, the regulatory framework and facility operations. The legal basis refers to a country's laws and statutes and its adherence to international norms and treaties related to nuclear and radiological material. The regulatory framework refers to the manner in which its laws are implemented through second order legislation and how nuclear activities are controlled. This requires a governmental body—or bodies—to be responsible for controlling nuclear activities. Finally, there are the facilities, persons, and activities that must be regulated. Although this chapter is chiefly concerned with the facility and operational levels, some brief points will be made regarding the legal and regulatory levels to provide a proper context for how organisational cultures are developed.

Legal basis

In the IAEA's 2010 'Handbook on Nuclear Law: Implementing Legislation', the 3S concept is used as a guiding approach to emphasise the interrelations between safety, security safeguards, and civil nuclear liability.[8] It highlights the need for legislation to reflect such interrelations in a comprehensive and synergistic manner. In the context of nuclear law, the 3S concept reflects the three technical areas that need to be addressed in establishing an adequate legislative and regulatory framework to ensure the peaceful uses of nuclear energy. Many IAEA Member States have recognised that measures taken to address one of these areas can contribute to addressing the others. One example is the adoption of suitable physical protection measures for nuclear material: protecting against unauthorised access to nuclear material can also help to ensure that it is used safely and only for the intended peaceful purpose. Another example is that a well-developed national regulatory safety infrastructure can help to ensure the security of radioactive material. Similarly, a well designed and implemented State System of Accounting for and Control of Nuclear Material, which is the foundation of country's safeguards system, can help to enhance security measures by appropriately accounting for nuclear material, which helps deter unauthorised removal of nuclear material.

Regulatory framework

Practical rules must be developed by a government and its organisations to govern and guide how nuclear activities are to be carried out in compliance with the laws. Chief among these governmental organisations is the regulatory body that is charged with controlling nuclear activities. The IAEA Safety Standards state that this regulatory body should be independent and competent.[9] This independence is crucial if its regulatory functions are to be separated effectively from any efforts to promote nuclear power and operations. This separation should maintain objectivity, fairness and transparency and avoid conflicts of interest. An important component of such independence is financial self-sufficiency. This helps the regulator to be free of external influences and to make sound technical decisions, be able to control activities using appropriate licenses and have the authority to enforce its rules. Moreover, its regulations should be as straightforward and clear as possible and avoid inconsistencies and inefficiencies. This last point plays a crucial role in how effectively safety, security and safeguards can be implemented by the staff at the facilities that are being regulated.

Laws and regulations provide a basis for all nuclear related activities occurring in a country. In this chapter, however, we are chiefly concerned with the activities in emerging nuclear power states; that is, those embarking on building a nuclear power plant and developing the underlying infrastructure to support nuclear activities. Such a programme will of course significantly increase the level of nuclear activities in a country. How much of an increase will depend greatly on the specifics of the country and the size of its planned programme. But regardless of the ultimate goal, a considerable amount of planning will be needed to deal with this increase in activities and importantly, in responsibilities.

Some of these new responsibilities will be straightforward, such as entering into the appropriate international treaties specific to nuclear power, such as the Convention on Nuclear Safety.[10] Other pre-existing responsibilities may need to be expanded or to become more complex. For example, existing security conventions and safeguards obligations will be significantly increased due to the level of nuclear material, related equipment and information being introduced.

Facility operations

The final level in this framework is the facility operations level. This includes users of the nuclear material and operators of the nuclear facilities. Such users and operators require clear laws and regulations to follow and an understanding of the consequences to their operations if they fail to comply with the laws and regulations. These consequences could be denial or revocation of licenses to use material, ineligibility to engage in nuclear related activities or to operate a nuclear facility, as well as fines and criminal prosecution. This is the level where the individual and the culture of the organisation play the largest role in determining if nuclear activities are performed safely, securely and only for peaceful uses.

The IAEA is developing a series of Safeguards Implementation Practices guides that are intended to provide best practices on the implementation of safeguards as part of a state's infrastructure.[11] IAEA Service Series 31 'Safeguards Implementation Practices Guide on Establishing and Maintaining State Safeguards Infrastructure', provides some practical examples of how safety, security and safeguards are intertwined within the legal, regulatory and operational areas of nuclear facilities and other activities involving nuclear material, such as those in hospitals or industry. It also explores some of the synergies between the 3Ss.[12]

The role of organisational culture and how it supports the safe, secure and peaceful application of nuclear power

The organisational culture can be regarded as the 'personality' of an organisation. It guides how employees think and act on the job, and it is a part of their values, beliefs and attitudes. Edgar H. Schein, Professor Emeritus in the Sloan School of Management at the Massachusetts Institute of Technology,[13] defines organisational culture as:

> . . . a pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems.[14]

Therefore, organisational culture is the group of shared values and perceptions of what are acceptable and unacceptable behaviors. Culture is a socially driven phenomenon where people conform to norms to gain the acceptance of the group and resulting benefits. Although it is not the purpose of this chapter to debate the definition of what constitutes a 'culture', it is important to understand what qualities a culture might have with regard to the safe, secure and peaceful application of nuclear power.

Culture cannot be directly imposed by the leaders of an organisation: it is established over time through the influence of a combination of leadership by example, communication and compliance with the management systems. Behaviors that are encouraged or enforced over time influence or define the culture. The best organisations value fairness, encourage taking responsibility for one's behavior, promote the feeling that individuals matter in an organisation, teach the need to maintaining a questioning attitude, have a common goal of excellence in operations, and meet stakeholders' expectations. Promoting and building this kind of organisational culture is the best way to achieve all the goals of a nuclear power programme, including its economic sustainability.

This is the key point for the countries developing the infrastructure for a nuclear power programme to understand. The same organisational culture that ensures the viability and (commercial) sustainability of the programme should also value the concepts of safety, security, and safeguards. It is already well established that safety is an integral part of this equation. This is true not only for the nuclear industry, but throughout manufacturing and heavy industries. Safety was initially seen as a burden, but it was eventually realised that companies with good safety records ultimately saw increased production and profitability.[15] This concept should also be applied to encompass security and safeguards to address the unique aspects of nuclear power.

Regarding safety, there have been concerns about radioactive releases due to system failure or human error since the inception of the nuclear industry. As a result, the nuclear industry benefits from a long-established, comprehensive and sophisticated safety regime. The IAEA supports this regime by establishing safety standards, providing safety services (such as operational safety reviews), and supporting the implementation of legal instruments that aim to achieve a high level of safety in nuclear power plants.

For nuclear security, recent events (in particular the terrorist attack in the US on 11 September 2001) have resulted in a renewed focus by the nuclear community on enhancing protective measures against sabotage or the theft of nuclear material at nuclear power plants. To help in this effort, the IAEA Office of Nuclear Security has recently published a new Implementing Guide aimed at helping countries understand what actions must be taken to establish an effective national nuclear security infrastructure for a nuclear power programme.[16]

Unlike safety and security, however, nuclear safeguards are not as well understood by individuals outside of specialised groups dealing with nuclear material, primarily because there are no parallels to it outside of the nuclear industry. Moreover, even if the concepts are understood, they can be easily confused with other terms. For example, the word 'safeguards' in some countries has a very negative connotation. In these countries, the word translated literally implies that people cannot be trusted, which is not the message management wants to convey to its workers. Thus, it is very important to take into account differences in the local cultural sensitivities when introducing the concept of safeguards and to translate the concept and not just the word.

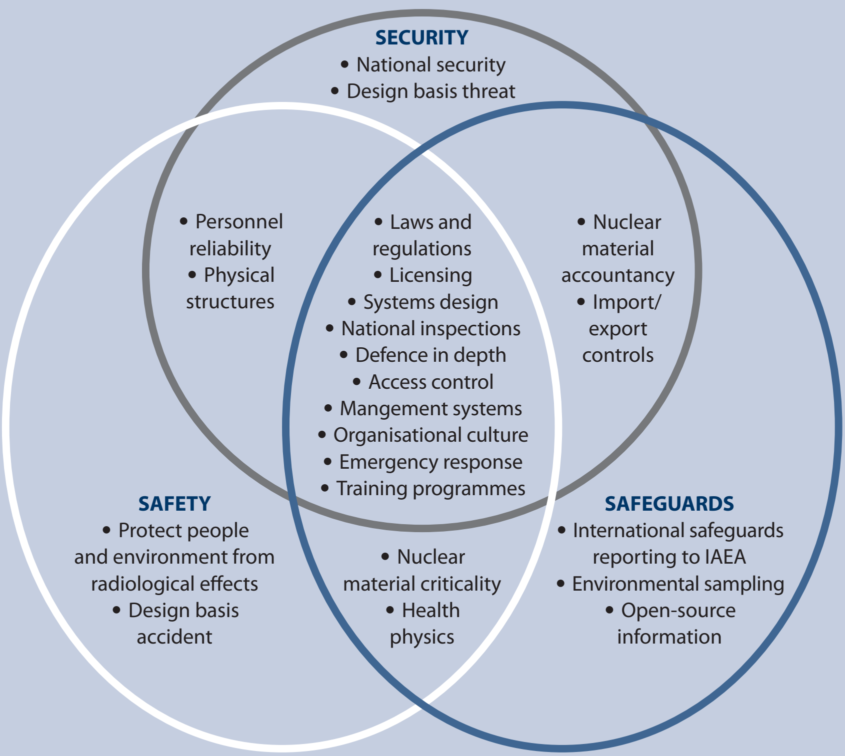
The application of international safeguards by the IAEA depends chiefly on national accounting for and control of nuclear material (sometimes called 'domestic safeguards'). Detailed nuclear material accountancy is unique to nuclear energy, and there is nothing equivalent to it in other industries as there is for safety and security.[17] This is especially true because nuclear material is unique in that it can be created or consumed by decay or transmutation—it can change from one element to another. This can be a limiting factor in how well the need for nuclear material accounting can be understood and accepted by facility staff.

Therefore, for safeguards to become a part of the organisational culture it must be included with safety and security, and their relationship must be clearly established by management. Since safeguards at operating facilities will likely be implemented by the same organisation that is responsible for safety and security, the integration of this concept into one organisational culture is the most effective and efficient approach.

Nuclear non-proliferation at the facility level not only includes concepts such as accounting for and control of nuclear material and physical protection systems, but also information and cyber security, along with export controls for equipment, information and material related to the nuclear fuel cycle. Non-proliferation is therefore not a standalone concept—a feature that underlines the importance of weaving safeguards issues into the wider organisational culture.

Additionally, nuclear non-proliferation extends beyond a nuclear facility and includes the government, its agencies, the regulatory bodies, academia and commercial and private entities. Nuclear non-proliferation includes adherence to bilateral, multilateral and international treaties, agreements and norms. It includes not only the

Figure 1 Examples of relationships between safety, security and safeguards for the national, regulatory, and operational levels



NPT and the statute of the IAEA, but also national security and control of illicit trafficking in material and information.[18] With such a potentially complex regime, it is doubly important that organisational cultures be cultivated at all levels in the country to include not only safety but non-proliferation as well.

Figure 1 provides a visual representation for some of the relationships between safety, security and safeguards for the national, regulatory, and operational levels.

Effective and efficient strategies for implementing safety, security, and safeguards in nuclear operations

Since nuclear operators must comply with a number of national and international requirements (through its government's international commitments) for safety, security and safeguards, the identification of effective strategies to more efficiently implement these requirements would reduce the burden associated with them. These strategies could help leverage the typically limited resources of countries where nuclear infrastructure development activities may be covered by a few organisations or individuals. Since the same organisations are typically called on to perform multiple duties, they should seek to determine how facility operational safety could be leveraged to benefit security and safeguards. This is because the underlying management and operational practices that are needed to implement all the requirements placed on a facility share a common infrastructure, so the best strategy is to make sure that those practices are compatible, mutually supportive and efficient. The term efficient is used to mean that energy expended in one area should benefit others.

Safely and effectively operating a nuclear reactor requires a high level of management commitment, support and organisational structure. It requires the application of advanced management concepts such as safety culture, quality assurance, self-assessment, risk assessment, configuration management, maintenance, design control, document control and records management, to name but a few. These concepts would also support the nuclear material accounting and control that is a part of the security and safeguards responsibilities of a nuclear operator. The organisational culture that exists for safe reactor operations would therefore support security and safeguards as well.

Another example is that the same technical safety skills required to effectively protect workers and the public from radiation exposure, to measure and characterise radioactive material, and to monitor the environment, all translate to the same core competencies and capacity of personnel and systems that implement aspects of safeguards and security, such as nuclear material accounting and control. The technical skills that personnel gain in characterising radionuclides for safety are directly transferable to measuring nuclear material (uranium, plutonium, and thorium), which can be applied to the effective application of safeguards.

Striving to develop a level of excellence in the management and operation of nuclear facilities that may exist in countries with small nuclear programmes will help immeasurably with the larger challenges as a country transitions to a future nuclear power programme. As such, the identification of interfaces and synergies between nuclear safety, security and safeguards is one of the chief ways to develop the best strategies that will benefit nuclear operators. The term 3S can be understood to describe a concept by which a country or organisation identifies and applies interfaces and synergies among nuclear safety, security and safeguards to more effectively and efficiently manage its nuclear activities and operations, while complying with domestic and international obligations.

These interfaces and synergies have been a subject of discussion in international venues in recent years. One such event that was held at the IAEA was a Technical Meeting on *Safety, Security and Safeguards: Interfaces and Synergies for the Development of a Nuclear Power Programme* that was held on 26–29 November 2012 in Vienna, Austria.[19] There were 40 participants from 24 IAEA Member States, the European Commission and the World Institute for Nuclear Security. Participating IAEA Member States included some who are embarking on nuclear power, some who are expanding their programmes and some with large, well-established nuclear power programmes.

According to the chairman's summary, most participants expressed a high level of interest in identifying the interfaces and synergies between the three areas of nuclear safety, security and safeguards to identify good practices for improved regulations and operations of nuclear power plants. It states that there are known synergies as well as challenges between safety and security and between security and safeguards. Several countries have discovered how to effectively manage the interfaces and take advantage of the synergies, which have provided tangible benefits to their existing nuclear power programmes. Several more are planning to take into consideration such experiences when building their infrastructures for their future nuclear power programmes.

Nuclear utilities and other operating organisations have found that applying an integrated approach for the implementation of safety, security, and safeguards in their facilities was in line with their business cases. An integrated approach provides for better compliance with regulatory requirements and improves the nuclear power plant's capacity factor, which results in a greater amount of electricity generation and profits.

There are a number of specific areas where good practices have been identified. A discussion of some of these areas is provided below:

- *Common objectives:* safety, security, and safeguards share the ultimate objective of protecting people, society, the environment and future generations from the harmful effects of ionising radiation and the misuse of nuclear material. This ultimate objective can form the basis for close cooperation between organisations of nuclear facilities, regulatory bodies and governmental organisations.
- *Nuclear law:* to avoid inconsistencies among different laws, a country's nuclear law should recognise the interfaces and interrelations between nuclear safety, security and safeguards as well as liability for nuclear damage. Measures to address one subject may contribute to addressing another. A 'comprehensive law' can include common elements that apply to different subjects, avoiding repetitions or cross-referencing of separate laws. Such a comprehensive law can be easier to access and understand by stakeholders.
- *Coordinated regulatory approach:* some countries have determined that a regulatory body that includes safety, security, and safeguards in 'one house' is the most effective and efficient approach. However, other countries prefer separate regulatory bodies for those functions. In both cases, close cooperation is still needed between those responsible for safety, security and safeguards (simply putting them into one house is not enough).
- *Clear requirements for the operator:* for the operator of a nuclear power plant, it is important that regulatory requirements pertaining to safety, security and safeguards are clear and that they do not conflict with each other.
- *Integrated management systems (IMSs):* the implementation of an IMS by a nuclear organisation that includes safety, security and safeguards, and their interfaces, ensures that these elements are effectively coordinated with each other, and that they are included in its core processes. Many management processes are common across an organisation's disciplines, functions, and roles and responsibilities.
- *Early design input:* the most effective approach would be to provide for all requirements in safety, security and safeguards during the design stage of a nuclear facility, or as part of the bid specifications. This approach optimises the site-design process and reduces the chance for expensive retrofitting or design changes that would hinder construction of the facility.
- *Human resources development:* human resources and workforce planning should support career development for employees that cuts across the disciplines of safety, security and safeguards. Crosscutting career development contributes to employee satisfaction and interdisciplinary sharing of experiences, and it supports communication channels between sub-organisations. This approach should also extend to contract personnel.

- *Common training programmes:* as part of a systematic approach to training, all relevant personnel should have a basic understanding of how safety, security and safeguards are involved in an nuclear power plant. It is more efficient to have coordinated training programmes that train individuals on common topics.
- *Emergency preparedness and response:* having a coordinated response is crucial during a nuclear incident. This necessitates planning, preparation, communication, collaboration and joint exercises between all stakeholders and organisations that will be involved in, or affected by, an emergency. A lack of coordination between organisations responsible for safety, security and safeguards—that may not be apparent during normal operations—could lead to serious problems in mounting an effective response during an actual emergency.
- *Communication with the public during an emergency:* during an emergency, it is important that information related to safety, security and safeguards be provided to the public (as appropriate) in a consistent and timely manner, and preferably using trained spokespersons (even when the event is occurring outside one's own country). Informing the public in this way can help to avoid miscommunication, instill public confidence and prevent the escalation of public concern.

There are also challenges identified in the implementation of safety, security and safeguards as listed below.

- *Culture:* if it is cohesive and well-oriented, culture can be a positive force in an organisation, but if it lacks these attributes it can also be a negative force. The attitudes and assumptions within the different disciplines of safety, security and safeguards may create problems in communication and cooperation among organisations. However, when the purpose behind each of the areas is communicated to the various stakeholders, they are better able to understand the role that each plays in a new nuclear power programme. This understanding can improve the implementation of each area and avoid problems that would arise from a lack of knowledge and conflicts of interest. The underlying factor is that individuals are usually not experts in all areas, and should therefore be made aware of the other disciplines.
- *Access versus security:* generally speaking, increased security results in less access and convenience. However, if facility personnel are made aware of the reasons behind any increase in security, they will likely respond with greater acceptance and compliance.
- *Lack of consistent terminology:* the terminology used in referring to the interfaces and synergies between safety, security, and safeguards is not consistent in the nuclear

industry and is therefore confusing. As such, it would be useful to develop a common understanding on using such terminology.

Potential areas for future collaboration between countries to support non-proliferation culture

Since several new countries are planning to initiate nuclear power programmes in the coming years, the burden will increase on an already-strained international safeguards system. These newcomer countries will require the infrastructures and related expertise to manage nuclear material and technology associated with the development of a nuclear power programme. The international safeguards system is challenged by evolving proliferation threats, expanding IAEA responsibilities and the diffusion of sensitive technology through illicit networks. It is up to the international community, and especially countries with well-established and mature nuclear power programmes, to collaborate with countries developing such programmes to address these non-proliferation needs.

The experiences of countries such as the Republic of South Korea (ROK) have demonstrated the benefits of partnering with countries that have successful nuclear industries and regulatory systems, and that require adherence to non-proliferation commitments. ROK made the decision to benefit from nuclear power and make it a key part of its energy and industrialisation strategy. It did this while adhering to all the relevant international safety, security and non-proliferation standards and obligations. It began its efforts by purchasing turnkey nuclear projects from countries with nuclear power technology, and built their capacity through technology transfer partnerships to develop its own indigenous capabilities. These partnerships were used to provide experiential learning and technology transfer to speed up domestic development. Even then, it took several decades of dedication to build significant industrial capacity. The development of organisational cultures that promote safety and non-proliferation are critical to this model.

One example of an outreach programme that focuses on international safeguards, security and non-proliferation is the US's International Nuclear Safeguards Engagement Program (INSEP). Its mission is to work with international partners to support and enhance nuclear safeguards implementation at all stages of civil nuclear development. These collaborations aim to improve the effectiveness and the efficiency of safeguards on nuclear material throughout the nuclear fuel cycle, and to support the non-proliferation regime by helping partners develop the appropriate infrastructures that support safeguards. For instance, a number of countries require legislative and technical support to prepare the infrastructure and procedures necessary to provide timely, correct, and complete declarations pursuant to the Additional Protocol (AP). As such, INSEP works with partner countries to strengthen their AP implementation. INSEP trains many practitioners from newcomer countries each year on international and domestic safeguards by drawing on the extensive technical expertise of the US national laboratory complex.

Organisations in other countries are also providing support for the implementation of security and safeguards for newcomer countries. Two such organisations are the Asia Pacific Safeguards Network (APSN)[20] and the European Nuclear Security Training Centre (EUSECTRA)[21]. The APSN is a professional network that draws on safeguards expertise in the Asia-Pacific region to facilitate the exchange of safeguards information, knowledge and practical experience among members to strengthen safeguards capabilities. Launched in 2009, APSN has helped its members improve the quality, effectiveness and efficiency of safeguards implementation by:

1. Supporting sustainable national nuclear safeguards capabilities;
2. Promoting regional cooperation in appropriate nuclear safeguards applications and practices;
3. Facilitating the coordination and the provision of nuclear safeguards technical assistance;
4. Providing a forum for sharing appropriate knowledge on nuclear safeguards; and
5. Developing a network of national nuclear safeguards practitioners in the region.

EUSECTRA instructs front-line officers, trainers and experts on how to detect and respond to illicit trafficking of nuclear or other radioactive materials. EUSECTRA offers hands-on training using a wide variety of radioactive and nuclear materials, and a broad selection of equipment and measurement instruments.

There are also international bodies, such as the IAEA, who work with countries to support them in their efforts. A recent report by the Brookings Institution outlines many of the political, legal and policy areas where experienced nuclear countries can work together or collaborate with third parties to help ensure that non-proliferation goals are achieved.[22]

However, there is still a need to find more effective approaches for experienced countries to reach out to countries developing nuclear power to share their experiences in a way that can best promote adherence to international obligations and treaties. What is still needed is *how* countries can achieve this most *effectively* and *efficiently*. This is where lessons learned can be of the greatest benefit for newcomer countries. For example, the experience of South Korea is that of a country that made a clear commitment to the utilisation of safe, secure and peaceful nuclear power for the benefit of its people, and made it a key part of its industrial development. While many countries do not necessarily seek this level of development, it is nevertheless instructive for them to learn from the experiences of countries like South Korea and others to take away those lessons, which are most relevant and useful.

Good nuclear organisational culture for a large country is not necessarily implemented the same way as a good nuclear culture for a newcomer country. This is because the number of people involved in nuclear activities in a newcomer country can be very limited at the beginning of its programme. Nevertheless, it is helpful for individuals involved in nuclear activities in newcomer countries to have the right 'mentor' at the beginning of their activities to ensure that the appropriate culture is instilled in the programme. This could have a cascading effect in a nascent nuclear programme as the concept of culture becomes ingrained into the mindset of the key individuals and the organisations and structures that they develop. At the very least, countries with well-established nuclear power programmes (or, for the purposes of the following section, 'experienced countries') could have a significant role in working together to share their experiences on how they developed and nurtured the proper organisational cultures to ensure that non-proliferation was integral to them. Below are some of the principal areas where the countries with established nuclear power programmes could strengthen their collaboration for the benefit of newcomer countries:

- *Supporting and strengthening nuclear law:* experienced countries should continue to support the IAEA in its efforts to help countries form the foundation of their nuclear programmes by ensuring that non-proliferation is integrated with safety and other aspects. The IAEA has a unique role in the global non-proliferation regime—one that demands that it maintains its objectivity and neutrality. The IAEA cannot act as both consultant and regulator. This is where collaboration with peers can give a country the confidence it needs to fully examine its nuclear legislation and to implement laws that allow it to fully meet its international obligations.
- *Supporting the development of robust regulatory frameworks:* the nuclear regulatory bodies in experienced countries should work to support the development of a regulatory framework that strengthens the domestic aspects of security and safeguards.
- *Export controls:* experienced countries should work together to support countries in developing robust export controls on trigger list items, as well as dual-use items. This goes beyond just advocating the signing of treaties and agreements, and includes continuing education and training of the countries' government, private and front-line organisations as well as the development of strategic plans and roadmaps to ensure that these efforts become sustainable.

- *Sharing best practices in operations:* this is perhaps the area that is most needed because it is the most neglected by international organisations. This is where true peer mentoring is needed because it is only personnel from operating nuclear facilities that can truly understand and communicate how to build excellence in operations within other facilities. International organisations either lack this cadre of experienced personnel, or do not have the mandate to provide assistance at this level. This is also one of the most difficult because it requires organisations that typically have the least time and effort to spare to provide time and effort toward this cause. Organisations that are truly world-class are such because they are highly focused on their own operations, and do not normally allocate time and effort to train outside organisations. Historically it has been left up to the countries seeking assistance to exert their own significant time and effort to locate such expertise. However, if true global non-proliferation is to be achieved, it is in the best interest of experienced countries to find ways to engage their nuclear power industries and incentivise them to contribute and become structured partners by providing increased opportunities for countries seeking assistance. This has already been done to a significant extent in nuclear safety with organisations such as the World Association of Nuclear Operators because of the accepted reality that 'an accident anywhere is an accident everywhere.' Such international mentoring and collaboration should also be established for security and safeguards because the same mantra *should* be true regarding a proliferation incident.
- *Providing access to nuclear facilities:* this goes hand in hand with the previous issue regarding sharing best practices in operations. Access to facilities in countries with large established nuclear programmes is critical if partner countries are to truly experience safeguards and security in action. Humans are hardwired to learn from their own experience and from what they physically see and do. Seeing organisations in action and witnessing how they 'practice what they preach' is invaluable in instructing individuals on how these sometimes abstract concepts are actually put into practice. This too is a difficult issue, especially with regard to tightening security requirements at nuclear facilities. These security postures should be implemented with common sense, and the understanding that adequately vetted individuals from legitimate nuclear programmes from eager countries are not just casual visitors or observers, but critical partners in global security and safeguards. It will be a missed opportunity if such individuals are not allowed to experience for themselves and take back the lessons to the organisations in their home countries. It is important to distinguish here between sensitive information and the process of security and safeguards. Students do not need to know about specific security measures such as location and types of security cameras or the location or amount

of nuclear material. What they do need to know are the systems and processes that are in place to secure and control a facility and its nuclear material, and they require information regarding how those systems and process were developed to fit specific situations and requirements. No sensitive information need be exposed; rather there should be a willingness by staff in an organisation to share relevant knowledge about processes.

- *Strengthening emergency preparedness and response to nuclear emergencies:* any dysfunctions in how safety, security and safeguards are implemented and interact will become readily apparent during an emergency involving nuclear material or a nuclear facility. These programmes are strong in countries with large established nuclear power programmes and are part of the facility operations, and include periodic exercises to challenge and improve the system. They should work together to share their experiences to support newcomer countries.
- *Improving communication and stakeholder involvement:* as was already discussed, non-proliferation is not very well understood by the majority of nuclear workers, and even less by the general public. Experienced countries should work together to support outreach and communication with stakeholders and the public in the countries to educate them about safeguards and security and other elements of the non-proliferation regime.
- *Sharing best practices for implementing integrated management systems:* experienced countries have significant experience in this area that could be of great benefit to newcomer countries as practical examples of how domestic elements of safeguards and security are integrated into safety as well as other operational aspects of nuclear facilities.
- *The value of early design input for safeguards and security:* the incorporation of early input of security and safeguards into the facility design can yield not only cost savings, but significant improvements to how the facility and the country can comply with its non-proliferation commitments. Some experienced countries are also nuclear power technology suppliers, and as such they can be influential in supporting this concept as well as providing lessons learned that can benefit newcomer countries.
- *Development of indigenous education and training programmes to develop adequate human resources:* to a degree, experienced countries are already supporting the development of education and training programmes for newcomer countries; this allows the newcomer countries to develop the human resources and workforce needed for their domestic nuclear programmes. However, more work is needed to support the universities and research organisations that contribute the technical expertise

needed in the development and implementation of these programmes. Supporting university curriculum development, encouraging partnerships between universities, supporting visiting professorships and student fellowships, developing training centers and providing access to nuclear facilities will help countries leverage their limited resources.

Concluding thoughts

It is sometimes said that 'culture is what is left when you have forgotten everything.' This is an amusing way to state that culture is a hard-to-define quantity that permeates the fabric of day-to-day activities. Translated to an operating nuclear facility, it includes the underlying theme of how the plant is operated, maintained, secured and safeguarded. The infrastructure that supports safety, security and safeguards is the most tangible aspect of this culture. Developing the proper infrastructure as early as possible in a nuclear power programme is very important in ensuring the sustainability of the programme, as well as providing the international community with positive assurance that nuclear activities in the country are for peaceful purposes. As such, security and safeguards are part of this infrastructure, and should have the same standing as safety. But because of their unique application to nuclear energy, these concepts are sometimes not well understood, and thus effective strategies must be crafted to make sure these concepts are given the appropriate consideration during the nuclear programme development period. The integration of security and safeguards with safety, and taking advantage of commonalities between them is one such strategy.

In the end, safety, security and safeguards have a common premise: they are all 'preventive' techniques, and as such there is a definite relationship between the legal, regulatory and operational aspects of their implementation. The lessons learned in universal acceptance and adherence to a safety culture in the nuclear industry can be used for the development of an organisational culture that supports security and safeguards as well. Because of their interrelatedness with safety, effective security and safeguards implementation is not possible without the basic framework provided by safety culture. Safety culture is well established, and security culture is becoming better understood, but safeguards culture is not widely understood outside specialised disciplines. However, safeguards are the lynchpin of a state's compliance with the global non-proliferation regime, and will work best if considered from the beginning.

Regarding the term 'culture', there is no sense in trying to develop separate cultures for safety, security and safeguards when dealing with a single organisation. Although each discipline has its own unique attributes, the same basic tenets apply to all of them. A sense of personal responsibility to make sure each job gets done right, a proactive management that supports and awards appropriate behavior and supplies the necessary resources for its personnel and facilities, a spirit of cooperation between individuals in different job functions towards a common goal, a sense of empowerment by employees such that they know that their concerns will be heard and considered, a workforce that has the necessary education, skills, and training to perform its duties, and a questioning attitude that considers the task at hand rather than rote adherence to static procedures are all hallmarks of a good organisational culture. And with regard to security and safeguards, the main task should be to craft effective strategies to help newcomer countries better integrate them within their respective organisational cultures.

Ultimately, this integration will better meet the needs of the newcomer countries, which is one of the highest priorities for the IAEA and the technical assistance it provides under Article IV of the NPT. Given the limited resources all nations face, support from experienced countries to promote the development of organisational cultures that supports security and safeguards in new nuclear power countries is paramount if they are to achieve sustainable nuclear programmes that are safe, secure and peaceful and provide the maximum in benefit for economic development and prosperity.

The views and opinions expressed herein are of the author and do not necessarily state or reflect those of the United States Government or any agency thereof.

Endnotes

1 *Milestones in the Development of a National Infrastructure for Nuclear Power*, NGG3.1 (Rev. 1), International Atomic Energy Agency, Vienna, 2015.

2 IAEA Nuclear Security Series No. 7, Implementing Guide, Nuclear Security Culture, Vienna 2008.

3 United Nations General Assembly Session 1 Resolution 1, *Establishment of a Commission to Deal with the Problems Raised by the Discovery of Atomic Energy*, A/RES/1(I), 24 January 1946.

4 US Department of State, Office of the Historian, history.state.gov/milestones/1945-1952/baruch-plans

5 Article IX of the NPT, paragraph 3, states that 'for the purposes of this Treaty, a nuclear-weapon state is one which has manufactured and exploded a nuclear weapon or other nuclear explosive device prior to 1 January 1967.' At that time, the NWSs were the United States, Soviet Union, United Kingdom, France, and China.

6 World Nuclear Organization–Emerging Nuclear Energy Countries. www.world-nuclear.org/info/Country-Profiles/Others/Emerging-Nuclear-Energy-Countries/.

7 www.iaea.org/newscenter/statements/atoms-peace-21st-century-1, Atoms for Peace in the 21st Century, IAEA Director General Yukiya Amano, Energy Market Authority Distinguished Speaker Programme, Singapore.

8 *Handbook of Nuclear Law*, International Atomic Energy Agency, Vienna, 2008.

9 'International Atomic Energy Safety Standards, Fundamental Safety Principles, Safety Fundamentals', SF-1, Vienna 2006.

10 The Convention on Nuclear Safety is a 1994 IAEA treaty that governs safety rules at nuclear power plants in state parties to the convention (INFCIRC/449). The convention creates obligations on state parties to implement certain safety rules and standards at all civil facilities related to nuclear energy. These include issues of site selection, design and construction, operation and safety verification and emergency preparedness.

11 The term 'State' is used to denote an IAEA Member State (country). In this chapter the term state is used synonymously with country.

12 IAEA Service Series 31 'Safeguards Implementation Practices Guide on Establishing and Maintaining State Safeguards Infrastructure,' Vienna, 2015.

13 Edgar H. Schein is credited with first using the term 'corporate culture.'

14 Schein, Edgar H., *Organizational Culture and Leadership*, Third Edition, John Wiley & Sons, San Francisco, 2004.

15 In the past five decades, industries in countries such as the United States have realised that where adequate laws exist and regulations are enforced, organisations and companies that place a prime value on the safety of their workforces and the quality of their products generally also have the highest levels of productivity, competitiveness, and profit (in other words, sustainability).

16 IAEA Nuclear Security Series No. 19, 'Establishing the Nuclear Security Infrastructure for a Nuclear Power Programme.'

17 The closest analogy would be to financial accounting where currency is strictly controlled and accounted for, and its movement is tracked.

18 One example of such an international instrument is United Nations Security Council Resolution 1540, which affirms that the proliferation of nuclear, chemical and biological weapons and their means of delivery constitutes a threat to international peace and security. The resolution obliges states, inter alia, to refrain from supporting by any means non-state actors from developing, acquiring, manufacturing, possessing, transporting, transferring or using nuclear, chemical or biological weapons and their delivery systems. It also imposes binding obligations on all states to adopt legislation to prevent the proliferation of nuclear, chemical and biological weapons, and their means of delivery, and establishes appropriate domestic controls over related materials to prevent their illicit trafficking. www.un.org/en/sc/1540/.

19 Technical Meeting on Safety, Security and Safeguards: Interfaces and Synergies for the Development of a Nuclear Power Programme, 26–29 November 2012, International Atomic Energy Agency, Vienna, Austria, www.iaea.org/NuclearPower/Meetings/2012/2012-11-26-11-29-TM.html.

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CHAPTER 5

Investigating multilateral verification of nuclear disarmament: fuel cycle modelling for simulations

David Keir and Russell Moul

Introduction

This chapter describes research directed by VERTIC and funded by the Government of Norway. The project, known as 'Supporting Multilateral Verification of Nuclear Disarmament' (MVND) engages the expertise of more than 50 researchers drawn from about a dozen organisations in seven countries.

The project aims to support the development of technologies and procedures that will enable a multilateral approach to verifying nuclear disarmament. It investigates how an intergovernmental organisation (IGO), such as the International Atomic Energy Agency (IAEA), can verify a wide range of nuclear disarmament scenarios. Accordingly, the project places an emphasis on verification of the whole nuclear fuel cycle, rather than focusing on warhead dismantlement alone.

A key feature of the MVND project has involved creating multiple nuclear fuel cycle models of hypothetical nuclear weapon states, to provide baseline data for disarmament simulation 'test-beds'. This data provides a research platform, which government, non-government and international actors can use to explore verification challenges in a range of hypothetical scenarios. This chapter will discuss the construction of these models, and how they can be used for the investigation of verification challenges.

While it is possible to conduct a desk review of the various technologies, procedures and methodologies applicable to future verification challenges, there is presently little ability to thoroughly explore any specific and practical situations in depth. There are, however, several valuable efforts in this field that are worth noting. For example, live-play scenarios have been carried out with personnel on the ground in real and mocked-up nuclear facilities, dating back as far as 'Project Cloud Gap' in the 1960s, which aimed to test the feasibility of potential arms control and disarmament measures. The project culminated in 'Field Test 34', an experiment exploring how nuclear weapon dismantlement might be verified.

In the 1980s, the 'Black Sea Experiment' showed that the US and Soviet Union had identified the value of working collaboratively to understand how monitoring technologies could be used to identify a real nuclear warhead deployed on a Soviet Cruiser.

By the middle of the 1990s, optimism for nuclear arms control had grown significantly in the US. The US Department of Energy's Office of Arms Control and Nonproliferation commissioned technical studies into the monitoring of nuclear warhead dismantlement with the expectation that such actions would be included in a third Strategic Arms Reduction Treaty (START) between the US and Russia. This was optimistically expected to include provisions for warheads on both sides to become treaty accountable items.

At a similar time, the Trilateral Initiative brought the US, Russia, and the IAEA together for collaboration, exploring techniques for verifying the transfer of military plutonium (the fissile material used in key components of nuclear weapons) to civilian uses. Over the course of 98 meetings, the initiative surveyed current measurement equipment (starting with approved IAEA equipment), and gradually developed an agreed measurement methodology, including a statement of equipment requirements. This was translated into detailed functional specifications and designs, which informed the creation and demonstration of prototype equipment.

Also, in 2000, the US and the UK started an on-going cooperation to explore technologies and methodologies. These included ways to allow foreign inspectors to enter a nuclear site and make monitoring measurements, without revealing sensitive information ('managed access'). Additionally, the co-operation studied 'information barrier' approaches to protecting classified data, while allowing inspectors to maintain continuity of knowledge over monitored items, and to gather information about the authenticity of these declared items. These efforts were aimed at developing widely applicable solutions that would enable the monitoring and verification of potential future nuclear disarmament initiatives.

More recently, further collaborative work between countries has been taking place. The UK and Norway—with contributions from VERTIC—established an initiative to assess approaches to non-nuclear-weapons-state involvement in verifying nuclear warhead dismantlement. The work initially focused on the need to control proliferative information and promote understanding between nuclear weapons states and non-nuclear-weapons states on verification constraints. In 2010, the UK–Norway Initiative also started to investigate a broader context for its warhead dismantlement work.

In 2015, the US Department of State and the Nuclear Threat Initiative launched a partnership with an international focus on nuclear disarmament verification. The International Partnership for Nuclear Disarmament Verification (IPNDV) aims to assess approaches to monitoring and verification across the nuclear weaponisation lifecycle. The IPNDV held its second plenary meeting in Oslo in November 2015, where it finalised the Terms of Reference for each of the three working groups that are established under the Partnership, and decided to focus its attention on warhead dismantlement as a first priority, while acknowledging that at a later stage consideration of wider aspects of the nuclear weapons cycle would need coverage too.

Also in 2015, the UK–Norway Initiative announced that it will seek to work with additional countries. In addition, recently, a group of research institutes in Germany have come together to form a 'nuclear disarmament verification network' to discuss and explore technical approaches to verifying nuclear disarmament. A 2015 publication by the network recommends that their collaboration should be expanded to the European level, drawing on a wealth of nuclear verification experience on the continent.

Despite these efforts, testing verification solutions on real facilities and materials is often expensive, legally complicated and politically sensitive, and opportunities to do so remain largely out of reach. The UK–Norway Initiative, for instance, has provided valuable insights into verified warhead dismantlement, but not with real warheads, and not in real operational areas of nuclear weapons dismantlement facilities. Progress has been gradual and restricted to one aspect of nuclear disarmament.

Building on all this previous work, VERTIC's MVND project has begun to develop 'verification simulations'. The purpose of these simulations is to enable groups of stakeholders to discuss, negotiate, and test individual or integrated procedures and equipment for verifying hypothetical disarmament environments. These simulations are created by combining detailed nuclear fuel cycle models with a variety of potential disarmament scenarios, creating a test-bed environment to generate a broad range of consistent, coherent and realistic verification challenges.

This chapter will discuss the methodology for constructing the model component of these simulations. In order to appreciate the value of a model, it is first necessary to understand its intended end purpose. Accordingly, the next section will briefly describe how models can be paired with a variety of hypothetical scenarios to form the simulation environments, before moving on to describe the step-for-step process of constructing a model and providing examples that have been developed by VERTIC.

Modelling research based on the creation of realistic modelled states

Simulations

It is not unusual for arms control, disarmament and non-proliferation regimes to use simulations to explore or test practices and procedures. Through simulations, participants can practice activities in a non-classified, apolitical, repeatable and focussed manner, which help to build confidence that verification is achievable. Replicating real disarmament activities—and the technical, legal and political dynamics surrounding them—in a more hypothetical setting can identify the strengths and weaknesses of potential disarmament verification approaches while avoiding the possible consequences of getting a real-life activity wrong. The use of simulations is, of course, a tried and tested technique used in a large range of public and private sector activities, as well as in the military.

Simulations designed to investigate verification challenges must be implemented in a way that maximises the value of their contribution to disarmament verification efforts. It is important to agree on a clear objective for the simulation—what it aims to achieve in the real world. This overall objective should guide the design and generation of the hypothetical disarmament scenarios and the modelling of nuclear weapons programmes so that they can be of most use for exploring the simulation tasks.

The design of the simulations must provide a detailed and credible environment from which simulation 'players' can complete their tasks without recourse to preconceptions or prejudices. This environment needs to be described in a coherent and unambiguous way so that it can be understood and held in the minds of each simulation player—the substance of this environment is thus generated through information such as maps, diagrams and data reference materials. It is these elements that are produced as part of the scenarios and models.

At present, the simulations being developed by the MVND project consist of the following components:

- *Disarmament scenarios*: these portray a specific, discrete instance of disarmament, which can be based on existing or hypothetical countries and international agreements. These scenarios provide the political and legal context for the disarmament activities. They include both a comprehensive overview of the country's history, international relations, and approach to nuclear weapons and technology, as well as highly detailed information on the commitments and requirements for disarmament and verification—for example, through a fictitious disarmament agreement.
- *Nuclear fuel cycle models of nuclear programmes*: these represent a country's nuclear fuel cycle, from the acquisition of nuclear source material through to weapons production, providing detailed information on individual nuclear facilities and on mass flows of nuclear materials. Nuclear fuel cycle models are prepared through research, calculations and dedicated software, with the aim of providing as realistic a picture as possible.

Each model is designed to supply quantitative data on nuclear material production, use and storage for any given period of time (usually year-on-year). The nuclear fuel cycle models are detailed representations of military and civilian nuclear fuel cycles that describe—in as much detail as is practical—the fictitious state's nuclear history. They describe when facilities were built and entered into operation, as well as the operating conditions of those facilities and the types and quantities of materials involved. These 'building blocks', which allow the reconstruction of entire nuclear complexes, have been researched and selected by VERTIC researchers, in consultation with other experts from the nuclear industries, including military production environments.

Ultimately, the facility layouts and the fissile material data produced by the model, together with an appropriate disarmament scenario, provide the foundation on which simulation players can begin negotiations for a formal disarmament verification agreement and, subsequently, for a variety of other more detailed 'verification solutions'. Achieving this requires simulating the movement or transformation of nuclear materials—from nuclear weapons dismantlement through to storage and accountancy of these materials. Additionally, larger issues such as securing and decommissioning the many upstream fissile material processes involved in nuclear weapons production will also be modelled.

For all these process streams, key process points (where monitoring would most effectively be placed) need to be identified and verification procedures devised, agreed multilaterally—and formalised as an agreement or protocol. Potential 'verification solutions' (for example, likely types of monitoring technology) for these key locations, plus the bigger picture of achieving confidence in a complete verification scheme, can be explored through table-top, live, or virtual exercises.

These solutions can be validated against the modelled data and also against further sensitivity studies.

VERTIC is in the process of devising role-play simulation exercises by combining the models and scenarios that have been created in the MVND project. It is intended that invited subject matter experts will conduct these simulations in the form of a series of tabletop exercises. The combination of the example country model and the accompanying scenario provides a credible history for a country that will be used as a basis for these role-play exercises.

Participants in these simulations will identify key aspects of each scenario (from baseline declarations through to long-term monitoring) and will be asked to test the application of various verification approaches that have been identified through desk review of existing technologies, procedures and methodologies. The virtual world within which these tabletop exercises will operate will also, given their detail, allow participants to identify unexpected verification challenges, investigate and devise new approaches to overcoming these challenges, and, ultimately, generate lessons-learned, that help prepare future inspection teams for hitherto under-explored scenarios.

Alternatively, instead of involving subject-area specialists to explore and identify verification solutions, the simulations can be oriented for use as a capacity building exercise for stakeholders who are unfamiliar with disarmament verification and want to learn more about it and engage in the area.

Scenarios and a scenario template

For the models we have described to be of use, they must of course be based on realistic assumptions and data. Therefore, the MVND project established a credible 'scenario' to provide a legal and political background for each model, and for each subsequent tabletop simulation. Ultimately, the scenarios form a context for simulation participants to help them understand the simulation environment.

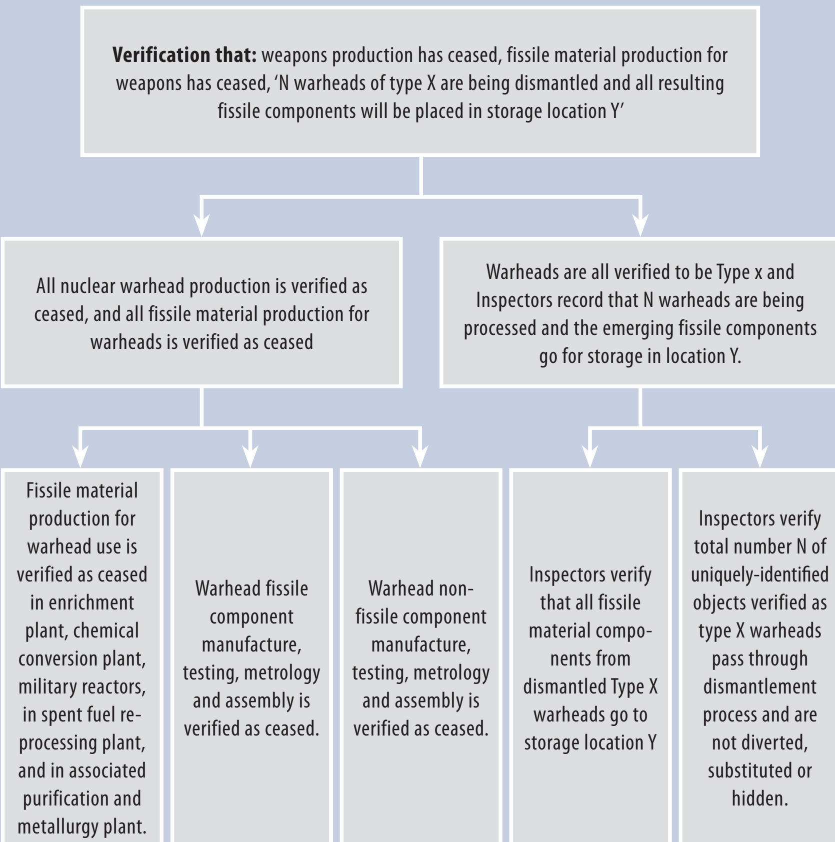
To optimise the simulation's effectiveness, it is important to provide all of the necessary information, without burdening the participants with superfluous details. With this in mind, and especially considering that the long-term objective of the MVND project is to have a series of different scenarios, covering a range of political and legal conditions, VERTIC and its project partners decided to create a *scenario template*, to be used when developing each scenario. This template is based around a series of questions about key variables, and various scenarios are created depending on the answers.

Key questions are:

- Is there an agreement or treaty governing the activities in the scenario? If so, who is party to this agreement, when was it signed, when did it enter into force, and what are its main obligations and subsequent verification tasks (such as the deactivation of nuclear activities, the disposition of material, or dismantlement of nuclear weapons)?
- Which country or countries will be the focus of the simulation (the modelled state and its treaty-partners)?
- Who is involved in the verification process?
- What is the state of relations between the various parties involved? Are any of the parties former adversaries, or allies? What, therefore, is the level of confidence required from the verification process?
- What is the agreed time scale for the activities taking place?
- What declarations are to be provided by the inspected state?
- What legal limits are there to the verification inspections (such as the obligation to ensure that no proliferation-sensitive data are released during the verification procedure)?
- Has the inspected state raised any political objections or set any specific limits on the extent to which verification activities can be conducted?
- Are there any nuclear safeguards agreements with the IAEA in place in the disarming country, prior to the verification process?

The answers to these questions provide the 'scenario': a detailed description of the undertakings to be verified, the context in which these are agreed, and the basic outline of how such an agreement will be verified. In doing so, they contain the seeds of both the technical and the political challenges that have to be overcome to successfully verify the hypothesised agreement. The disarmament scenarios produced also provide simulation participants with specific fictional roles, such as international inspectors, representatives of the inspected state or facility operators, and imply a number of specific activities or issues for which effective verification solutions must be applied.

Figure 1 A Logic-based breakdown of example declaration verification requirements at the beginning of a nuclear disarmament scenario where all military production is ceased and all warheads are to be dismantled



Main verification requirements—what kind of processes and items are important?

Charting the generic components of a verification scheme can provide a useful guide for devising of tabletop simulations.

Figure 1 above is a logic-based picture of a comprehensive verification scheme. It shows, in a hierarchical way, what a verification scheme should be confirming for a generic situation based on multiple types of treaty-accountable item at multiple locations in a nuclear complex.

Each descending level of the diagram unpacks the overall aims into successively more detailed components. This diagram represents only the top few levels level of what could be extended several more layers down, using Boolean logic to ensure that a complete picture is produced. Further elaboration of this technique is beyond the scope of this chapter. But, in summary, development of such a diagram moves toward identifying, at the lowest tier, the individual aspects and individual locations for which on-the-ground verification systems may be required. Equally, this sort of breakdown gives an indication of what level of detail is required in the modelling of the nuclear complex and its processes.

The research examples—modelling a fictitious nuclear fuel and weapons complex and the method used

The process for creating a fictitious nuclear complex history can be understood as a series of four stages that progress from broadly defined concepts to detailed specifics, and then onto the generation of applicable data. Essentially, the construction of each model progresses through four stages:

1. A principal decision on the type of country to be modelled;
2. Conducting desk-based open-source research to establish a credible timeline for the imagined state's history, available technology and operating conditions;
3. Producing a draft storyboard for the imagined state's nuclear industry development; and
4. Generating and gathering data for each facility for each year of the state's nuclear timeline.

Stage 1—concept stage

In this stage, research focuses on devising a suitable profile for the notional country to serve as a base on which a nuclear fuel cycle model and the main features of the state's nuclear weapons programme can be developed. To devise the profile, key decisions are made about the type of state that will be modelled. To allow the simulation of a broad range of potential verification challenges, the models developed under the MVND project represent an array of possible nuclear programmes of varying size and configurations. This enables researchers to identify whether different challenges emerge when different scenarios are applied to countries with nuclear programmes of varying sophistication and complexity.

At one end of the spectrum, models could represent a state with a highly-developed nuclear weapons programme complete with both military and civilian fuel cycles, overlapping nuclear material flows between the military and civilian cycles and a large stockpile of nuclear material, weapons and propulsion reactors.

At the other end, a model could represent a nation with a new and burgeoning nuclear capability, manifested by a single fuel cycle used for both military and civilian purposes, few nuclear weapons and an aspiration to develop an enrichment plant. Such a model, called 'Example Country 2', has been fully developed.

Another model, named 'Example Country 1', has been designed to strike a middle ground by modelling a country with distinct medium-sized civilian and military programmes, a nuclear arsenal of a few hundred weapons and a small nuclear naval programme.

Guided by the state's profile, the next step involves carrying out case study research into similar historical nuclear weapons programmes that relate to that type of state. For example, if the aim is to create a small nascent nuclear weapons state that undertook a heavily clandestine approach to weapons proliferation, like Example Country 2, then historical information can be drawn from the nuclear weapons programmes conducted by Iraq, Sweden, Libya, South Africa, Argentina and North Korea. This helps to establish a set of data for real-life examples, to inform the construction of the fictional models. Background questions asked in these information studies can include:

- What was the size, shape and distribution of their nuclear programme?
- Was any one nuclear weaponisation pathway prioritised over another?[1]
- Which relevant facilities/capacities were pursued, when, and in what geographical distribution?
- What was their approach to transparency?
- Did they misuse declared facilities for undeclared processes?
- Did they pursue a clandestine parallel programme?
- Were all of their nuclear activities clandestine?
- How did their geopolitical situation affect their decision to pursue nuclear weapons?

- How did their geopolitical situation affect the technical shape of their proliferation efforts?
- Were there any notable changes in approach, in response to successes/failures?
- While they existed as a nuclear state, were there any notable changes in approach in response to successes/failures that influenced the decision to abandon (or not to abandon) their nuclear efforts?
- To what extent did multilateral/bilateral agreements control the abandonment of their efforts (where relevant)?
- Who was involved in these agreements?
- How were they negotiated?
- How detailed were these agreements, and to what extent did they specify verification requirements?

By identifying themes and characteristics, this information gathering can be used to inform a broad idea of how each modelled state's nuclear complex should look like. It can help establish a fictional geopolitical history for each modelled scenario—the state's political identity and its relationship with the international community and the non-proliferation regime in particular—as well as its scientific and technological sophistication—the size of its industries, its nuclear ambitions, and its approach to developing nuclear technology and weapons.

From here, it is possible to draw-up an initial image of the fictional state's nuclear fuel cycle and the constituent parts that are required to produce its nuclear arsenal. For example, a decision can be made as to whether or not the state has developed independent fuel cycles for civilian and military purposes, or whether or whether the same facilities have been employed both for civilian use and for the production of material for nuclear weapons. The answer to this question dictates how the modelled state will behave and the types of technologies it will develop. This is further dependent on the modelled state's access to source material and on whether or not it imports or mines uranium indigenously.

Stage 2—fissile material demand

In this stage, key questions concerning the modelled state's nuclear weapons programme are addressed in order to establish a target for guiding the construction of a fictitious background history. This involves deciding on the final number of weapons that will comprise the state's nuclear arsenal, the arsenal's diversity (whether it will consist of one or more weapon classes), composition (whether the weapon cores are made of uranium, plutonium or both), as well as the number of nuclear weapons tests performed for each weapon class and the amount of fissile material consumed in each test. In addition to providing an end-point for the state's background history, this process also provides data relating to the breadth and sensitivity of the state's nuclear weapons programme, which is crucial information for the simulation exercises.

Stage 3—devising a background history

Once the modelled state has been given a suitable profile and a final number of nuclear weapons (plus nuclear explosive tests) and thus a fissile material demand, it becomes possible to devise a background history for the development of its nuclear programme.

This involves projecting backwards, from the present time, the number of years needed to achieve the target weapons and material production for the modelled state. If the model represents a sophisticated nuclear weapons programme, for example, with many thousands of weapons, then it will take an appropriate length of time in order to create the requisite material and to test and stockpile its weapons. In this case, the state may need a history of over 50 years, perhaps even 60–70 years. The starting year could then be expressed as T-60 or T-70 respectively, where T stands for *time* and the number represents the number of years leading up to T0, the year when the state decides to disarm. T0 represents the point where one can begin studying the verification of disarmament drawdown of nuclear material from warheads and weapons stockpiles.

In order to ensure that each facility in the model's timeline is credible, both in terms of the historical accuracy for the technologies it uses and for its overall coherence, the following needs to be considered carefully:

- How many years would it take to construct a given facility?
- How long will it take for a quantity of fissile material to pass through the facility?

Devising the timeline is an end-focused activity. It requires researchers to constantly balance facility construction and operations with sufficient material production in order to satisfy material demand for the weapons programme.

For each facility in the timeline, additional desk-based research should be conducted to ensure that it is equipped with appropriate technologies for the historical time that it is operating. There is little value in having a model that includes present day technologies that are inappropriate for earlier decades—anachronisms undermine the model's value. In addition, this research should build individual profiles for each facility in the fuel cycle. These profiles include details on that facility's specific operating conditions and properties. For example, if the state is developing enrichment capabilities, will it choose gas centrifuges? Which centrifuge design will it use and how many centrifuges will it house? What then is the enrichment plant's capacity and what fraction of that capacity does it manage to reach? When did it come on stream and when does it cease operations? What is its annual feed requirement?

Or, with respect to reactors, what type of reactor is being used? Is it optimised for civilian or military purposes? What is the quantity of fuel needed for each reactor. How long will fuel stay in the reactor, what is the downtime versus operating time and what is the maximum burnup for each irradiation cycle? The answers to these questions are fundamental for setting up the conditions for generating realistic output data from the model.

The process for establishing the timeline and plotting the operating dates for each facility in the modelled fuel cycle, in each worked example, entails balancing material requirements with the time it takes for a given fuel cycle process to be completed. For instance, if the state developed its own nuclear facilities and utilised indigenous uranium ore supplies, then the model will require mass transfer elements (single, fixed locations at which fissile material mass is tallied, used in the mathematical calculations for 'updating' a fissile material inventory as time passes in the modelling) representing mines and mills.

The timeline will need to take into account the number of months or years it takes to design and build these facilities, and to exploit the uranium deposits so that sufficient quantities of uranium has accumulated to feed the 'conversion' process (changing uranium oxide to uranium hexafluoride). The time this takes is dependent on the model's assumptions about the size and nature of its mine(s), and how rich the uranium deposit is.

If the imagined state does not have access to uranium mines, then it may import stocks of U_3O_8 to feed its nuclear programme. This could shorten the timeline by a few years. If so, then the first facility to enter into operations could be a conversion plant for producing uranium hexafluoride to feed an enrichment plant (if the state is utilising LEU fuel) and then a fuel fabrication plant.

This process could take a year or two to complete before fuel is ready for the nuclear reactor, especially if it uses a large core. In constructing the fictitious timeline for our example countries, it was found best, in practice, to decide on the start-up date for the reactors first. It was easier to work backwards from there in order to plot the rest of the timeline, as this provided a fixed date for when a specific amount of fuel needs to be created.

An example can be seen in Figure 2 below, which shows the timeline for Example Country 2, which is based on a fuel cycle that is not dissimilar to the one of DPRK. The diagram is broken down into specific decades that represent the major political events taking place in Example Country 2, on which the start-up dates for each fuel cycle component is plotted. The arrows leading from each facility span the years that the facility is in operation (black arrows indicate military use).

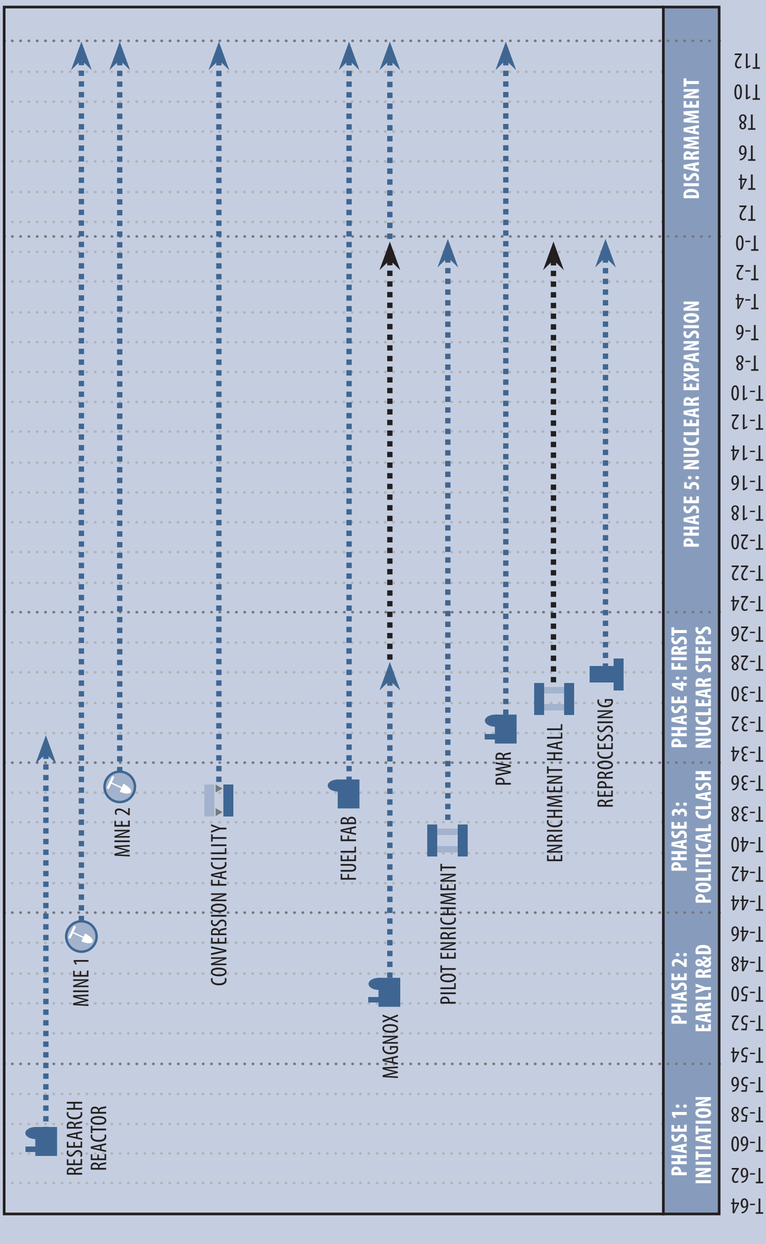


Figure 2 Timeline for construction of Example Country 2's nuclear complex

Stage 4—data generation

When generating information for nuclear fuel cycle models, a number of prerequisites need to be taken into account. Principally, there should be a clear understanding of what the model's purpose is and what type of information is needed to achieve it. As highlighted above, the process of building the model's timeline needs to be end-focused; the same is true for data collection. Without a clear understanding of what the purpose is, the model could be overloaded with superfluous information limiting its usefulness. Moreover, although many features of the civilian fuel cycle are well documented in open-source literature, the same cannot be said for military programmes and the details surrounding weapons production. Information for these processes is politically sensitive and potentially proliferative in nature. As such, the process of abstracting weapons-usable fissile material from the modelled fuel cycles and placing it into a nuclear warhead component is fraught with challenges.

Researchers developing a comprehensive model of a notional nuclear weapon state therefore have to negotiate between two extremes: on the one hand sifting through and selecting from a glut information on nuclear fuel cycles, and, on the other, contending with the paucity of information on weapons production and their material requirements.

When it comes to modelling civilian fuel cycle activities, simplicity should be the guiding principle: a model often derives its power from its ability to simplify its treatment of a process or phenomenon. It is therefore important for researchers to make key decisions on what information is essential to the model's purpose and what is additional or just nice to have. For the purpose of providing baseline data for disarmament verification simulations, the focus of data generation is fixed on the production of fissile material, fractional loses in any particular process, and logging fissile material holdings at specified locations, for the modelled programme's entire history. The model is therefore driven by capturing information for all stages of the fuel cycle and accounting for stocks of source material as they progress through the various chemical and nuclear processes in each facility, as well as those facilities' individual operating conditions.

The process for populating the model with data for fissile material production can be seen as a continuation of the timeline activity described above. Once the timeline has been established and is complete with all facilities, their individual start-up times, capacities, feed requirements and specifications, further research can be conducted into material production—this information will form the data for each facility.

There are multiple options available for generating this information depending on the type of state that has been chosen for the model. Obtaining information on the annual production capacities of most fuel cycle facilities is not difficult. There is an abundance of open-access resources and textbooks available that provide detailed descriptions and technical instruction for each stage of the nuclear fuel cycle, their operating conditions as well as calculations for estimating material production.[2] More specifically, significant scholarship has gone into reconstructing the technical histories of the existing nuclear weapons states. These resources can be used to piece together details for facility capacities and for annual material production.

Additionally, a number of potentially useful software packages exist that generate quantitative data for all or specific parts of a modelled fuel cycle. ORIGEN-ARP, developed by Oak Ridge National Laboratory, is one such piece of software that can model the production and consumption of nuclides as a function of time. ORIGEN-ARP can provide precise data for plutonium production in reactor fuel for both civilian and military reactors (the changing variable being the neutron flux and the length of time that the fuel stays within the reactor). For example, if the reactor being modelled is generating electricity for a civilian nuclear programme, then users can optimise the burnup to an appropriate level in order to maximise fission within a given reactor core load. Alternatively, users can lower the maximum burnup for the fuel and therefore produce plutonium that is better suited for weapons use.[3]

When it comes to modelling classified processes such as those involved in the weaponisation process, researchers must rely on approximated figures for various activities. For example, the IAEA's definition of a 'significant quantity' could be used as a standard for the quantities of fissile material used in modelled nuclear weapon.[4] If the modelled state has had an expansive nuclear history with multiple generations of weapons, different weapons classes and many explosive tests, then the model could use larger quantities of a given fissile material for earlier weapon generations and classes, and then gradually reduce this amount—this assumes that subsequent weapons tests and weapons classes will become more efficient over time and require less material.

Estimation sacrifices accuracy, but it does provide data that can be used in modelling and allows researchers to bypass certain issues associated with proliferative information that might be contained in open-source documents that speculate on how nuclear weapons are built.[5] Within the simulation exercise, reasonably approximated information can still be useful as long as the model is internally consistent.

This is crucial for modelling the individual processes involved in manufacturing weapons within a weapons complex. In this instance, not only are details about the weapons classified, but so are the technical and mechanical processes involved in assembling them. One way to model this process is to treat the nuclear weapons complex as a black box where specific quantities of material enter the facility, undergo a series of unspecified processes that then produce a final output product—a nuclear weapon with a pit consisting of an approximated quantity of fissile material. In this case, a researcher can assume that production process will result in a degree of material loss as the fissile material is shaped and machined to form the 'pit'—in the case of an implosion device. It is therefore possible to apply a standard loss fraction for this process and to record the estimated loss for each year of operations.

Facility sheets

In addition to the plotted timeline, each model can include a set of datasheets that represent fissile material inventories in each facility in the example country's nuclear programme—for both civilian and military fuel cycles, where relevant. These facility sheets are divided into three portions that account for the facility's input, operating process and its output for every year in the model's fictional timeline. So, for example, if the modelled state has a development history of 70 years, there will be an equal number of rows on the sheet to account for each one. The portions are then subdivided into columns that contain space for recording data on specific processes and the quantities of material (all measured in kilograms).

Once complete, the facility sheets contain quantitative information for the following:

- Facility type, and the year when it came online;
- The facility's operating conditions, properties and capacities[6] (for example, reactor burnup, maximum core load, thermal power or centrifuge separative work unit);[7]
- Quantities of material before, during and after a given process;
- Quantities of a specific isotopes of interest (^{235}U and ^{239}Pu) before, during and after a given process;
- Cumulative material in facility before, during and after a given process;
- Quantities of material being dispatched from a facility;
- Shut-down or refuelling periods;
- Loss factors for specific processes (for example, material lost during conversion of U_3O_8 to UF_6, fissile material loss during weaponisation processes);
- Tails or waste quantities.

Once collected together, the data in these tables form a material account for all facilities throughout the state's fictitious development history.

The following section will provide an overview of Example Country 2 which is the fully developed model developed under VERTIC's MVND project. Example Country 2 will serve as an example to highlight the various stages and features that constitute the final model timeline, fuel cycle facilities and some of the respective operating conditions. It should be noted that this is not an exhaustive example of all of the data contained within the Example Country 2 model, but just example features.

Worked example—Example Country 2

Example Country 2, its nuclear history and types of facility

Example Country 2 was originally designed to resemble a nascent nuclear weapon state whose fuel cycle was employed for both civilian and military purposes. The state was envisaged as having a small arsenal of 50–60 nuclear weapons by T0, at the point where it agrees to disarm. In essence, Example Country 2 is intended to resemble aspects of an actual country's nuclear programme—DPRK, which is of topical concern—so that the disarmament simulation can explore hypothetical challenges that might be presented by any future disarmament arrangement with that country.

1950s—initiation phase

In the 1950s, Example Country 2 obtained a research reactor through foreign assistance and development programmes. This facility was placed under item-specific safeguards (INFCIRC/66), and the spent fuel was sent back to the supplying country for reprocessing.

1960s—early R&D phase

In the mid-1960s, Example Country 2 was provided with two small 25 Megawatt thermal (MWth) gas-cooled, graphite moderated, Magnox reactors, which were used for generating electricity. Like the research reactor before them, this Magnox reactor was placed under IAEA item-specific safeguards, and the supplying country provided fresh fuel and retrieved it as spent fuel once it had been used in the reactors. The fuel for the reactor was irradiated (that is – used) for four years per cycle and reached a maximum burn-up of 700 Megawatt days per tonne.

During this time, Example Country 2 launched R&D programmes covering uranium conversion, enrichment, fuel fabrication, and spent fuel reprocessing as well as research into their own pressurised-water reactor (PWR) design for civilian power generation purposes.

1970s—political clash

Throughout the 1970s, Example Country 2 began operating key fuel cycle facilities: it began stockpiling indigenously mined uranium ore from its two large uranium deposits; it started converting and fabricating natural uranium fuel for its Magnox reactor while also producing low enriched uranium (at 3.03 per cent ^{235}U) for its PWR at a pilot enrichment plant (using centrifuges similar in design to URENCO G2 centrifuges). The fuel for both reactors was tested in the old research reactor. At the end of the decade, Example Country 2 took the final decision to develop nuclear weapons.

1980s onwards—steps to nuclear weapons

In the 1980s, the results of Example Country 2's nuclear research over the previous 20 years came to fruition. It launched a full-scale enrichment plant, its indigenously developed PWR and a spent fuel reprocessing facility. The enrichment plant began producing 90 per cent highly enriched uranium (HEU) to be used in its first generation of nuclear weapons. By 1991, Example Country 2 had produced 572.9 kg of HEU for its weapons programme.

By the end of the decade, Example Country 2 started using its own indigenously produced Magnox reactor fuel, as the fuel supply agreement it had originally stipulated came to an end. After introducing its own fuel, Example Country 2 ran the Magnox reactors to a lower burn-up compared to the previous irradiation cycles (from 700 Megawatt days per tonne to 160 Megawatt days per tonne), and refuelled it more frequently, once a year. This resulted in Example Country 2 producing approximately 8 kilogrammes of weapons-grade plutonium (97-98 per cent ^{239}Pu) with every irradiation cycle.

While initially Example Country 2's leadership thought that its own domestic PWR could be used for weapon-grade plutonium production as well, obtaining irradiated material of a sufficiently similar isotopic composition to be used in conjunction with the plutonium recovered from Magnox fuel proved to be difficult, and the PWR was eventually dedicated to civilian use only.

Example Country 1—an overview of its nuclear history and the types of facility modelled

Chronologically, the MVND project's first worked example was 'Example Country 1'—a medium-sized nuclear weapons state with two distinct fuel cycles—one dedicated to civilian power generation and the other dedicated to military activities. Prior to the decision to disarm, Example Country 1 was equipped with a medium-sized and modern nuclear arsenal of a few hundred ballistic missiles launched with two-stage nuclear warheads, a retired arsenal of gravity bombs as well as three nuclear propelled naval vessels. The disarmament scenario attached to this model dictated that Example Country 1 would enter into an agreement to disarm all of its nuclear weapons in a hypothetical multilateral disarmament situation, alongside all other nuclear weapons-owning states. Example Country 1 was imagined as an NPT Nuclear Weapon State, with a nuclear history dating from the mid 1950s.

Example Country 1 developed a small, but geopolitically significant nuclear arsenal by To when the multilateral disarmament situation started. The state had to rely on imports of U^3O^8 to fuel both its nuclear fuel cycles, as it did not have indigenous uranium deposits to utilise. Using the United Kingdom as inspiration, a decision was made to furnish the model with gas-cooled, graphite moderated Magnox reactors to be used for producing Example Country 1's weapons-grade plutonium. In order to prevent the model from completely resembling the United Kingdom, Example Country 1's civilian programme used pressurised water reactors that are similar in design to the Russian VVER-440s.

To keep the modelling simple, we chose not to mix military and civilian operations in the same facilities. Thus Example Country 1 does represent a slightly idealised and simplified picture, where discrete process lines are followed—from source material conversion, via enrichment, fuel fabrication, reactor operation, to reprocessing and plutonium product storage—in a dedicated civilian plant or a dedicated military plant. Although this has not been the case for many real-world nuclear states, it was seen as the best first option for this demonstration study. Example Country 1 is currently being updated to match the sophistication of Example Country 2. In addition, an important follow-on activity would be to complete a model that represents a large-scale nuclear programme that is similar to those of the US and Russia. This model could be matched with a scenario that involves a reciprocal disarmament agreement, with multilateral verification in operation.

Conclusion

The models developed under VERTIC's Multilateral Verification of Nuclear Disarmament Project are intended to provide quantitative data for fictitious nuclear weapon states that serve as a basis for conducting simulation exercises with selected disarmament verification scenarios. These models contain detailed information on the quantity of fissile material, number of warheads and related components in inventories for all parts of the fuel cycle. The information contained within each model can serve as baseline information for conducting tabletop or live play exercises for investigating verification solutions for a wide range of multilateral disarmament scenarios. They allow simulation players and control teams to identify unexpected verification challenges for specific facilities, to investigate and devise new approaches to overcoming these challenges, and to prepare future inspection teams for hitherto under-explored scenarios.

A useful next step for the modelled data described in this chapter is to use it as the basis for a tabletop negotiation simulation exercise whose overall objective is to devise a notional disarmament verification agreement between Example Country 2 and its neighbours. Within this exercise, Example Country 2 will agree to disarm its nuclear weapons programme and weapons stockpile and to place all of its military facilities under IAEA safeguards. The exercise will use the data to identify the technologies and procedures that might be needed to verify correctness and completeness of fissile materials emerging from Example Country 2's military programmes. These negotiations can explore the access and the degree of measurement intrusiveness that would be required by inspectors—and what would be tolerable to nuclear facility management in a disarming state.

In so doing, this type of simulation will aim to add to current debates on future non-proliferation and arms control verification activities, and can be used to help train and educate future inspection teams, students and professionals involved or interested in nuclear disarmament verification and non-proliferation studies.

While the worked-example simulations described here focus on the dismantlement of nuclear weapons and the safeguarded storage of special fissionable materials, these simulations could be carried out for quite different scenarios. For instance the methodology could be used to examine cases in which military programmes are merely scaled down, restrained, or only parts are discontinued, facilities converted to civilian use or otherwise decommissioned, or the safeguarding of previously undeclared activities or material, or broader constraints on nuclear activities.

The methodology developed could also be used to model expansion of weaponisation in real states, and to assess the impact on proliferation risk of expansion in civilian nuclear programmes.

Endnotes

1 For a description of the two routes to making a nuclear weapon, see chapter 2 in this volume 'Securing the front end of Iran's fuel cycle' by Andreas Persbo and Hugh Chalmers.

2 For a general overview of many aspects of the fuel cycle, see www.world-nuclear.org/info/Nuclear-Fuel-Cycle/. For a detailed discussion of nuclear reactors but also other aspects of the fuel cycle, see David Bodansky. *Nuclear Energy: Principles, Practices, and Prospects* (2^{nd} edition). New York: Springer, 2008. For a good detailed discussion of enrichment technologies, see Allan S. Krass, Peter Boskma, Boelie Elzen, and Wim A. Smit, *Uranium enrichment and nuclear-weapon proliferation*. Stockholm: SIPRI, 1983; and US National Academy of Sciences, *Monitoring Nuclear Weapons and Nuclear-Explosive Materials: An Assessment of Methods and Capability*. National Academies Press, 2004. For a good description of reprocessing, see *Spent Nuclear Fuel Reprocessing Flowsheet*, published by the Nuclear Energy Agency, Organisation for Economic Co-operation and Development. Paris: OECD, 2012.

3 The reason for this difference is that the higher the neutron fluency (the final burnup), the larger the proportion of the higher plutonium isotopes (^{240}Pu, ^{241}Pu and ^{242}Pu) builds up in the fuel. The most desirable isotope for nuclear weapons is ^{239}Pu. ^{241}Pu is fissile, but has a short half-life of 14 years (it decays into americium-241), which is an intense emitter of X-rays and gamma rays as well as producing heat, which needs to be dispelled. ^{238}Pu, ^{240}Pu and ^{242}Pu are also undesirable as they spontaneously fission at a higher rate than ^{239}Pu, producing higher energy neutrons and a considerable amount of heat. The neutrons emitted in this fission process increase the likelihood that the chain reaction in a bomb will begin before full compression of the plutonium has been achieved—causing pre-detonation.

4 The IAEA currently defines a significant quantity as 'the approximate amount of nuclear material for which the possibility of manufacturing a nuclear explosive device cannot be excluded.' For plutonium it is 8kg (for plutonium containing less than 80 per cent ^{238}Pu), and 25kg of ^{235}U in HEU.

5 See Richard Rhodes, 1986. *The Making of the Atomic Bomb* (New York: Simon & Schuster) and *Dark Sun: The Making of the Hydrogen Bomb* (New York: Simon & Schuster); Chuck Hansen, 1988. *US Nuclear Weapons: The Secret History* (Aerofax) and 'The Swords of Armageddon': www.uscoldwar.com/

6 Investigations into facility properties, optimal operating conditions and capacities were conducted as part of Stage 3 of the modelling process.

7 An enrichment plant's capacity is measured in terms of Separative Work Units (SWU). Simply stated, SWU stands for the effort required to separate ^{235}U and ^{238}U. The measurement indicates the amount of energy used relative to the amount of uranium processed, as well as the level to which it is enriched and the remainder is depleted. The unit is expressed in kilogram Separative Work Units, while the actual capacity of an enrichment plant is measured in tonnes SWU per year (tSW/a). For more information, see www.world-nuclear.org/info/nuclear-fuel-cycle/conversion-enrichment-and-fabrication/uranium-enrichment/

CHAPTER 6

Dealing with objections to the CTBT

Edward Ifft

Introduction

This chapter deals with a major piece of unfinished business—achieving entry into force of the Comprehensive Nuclear Test Ban Treaty (CTBT). This Treaty, called 'the longest-sought, hardest-fought prize in arms control history' by President Clinton, was negotiated from 1994 to 1996 at the Conference on Disarmament in Geneva. It has been signed by 183 countries and ratified by 164. According to the Treaty's provisions, it cannot enter into force until it has been ratified by 44 named countries. This chapter focuses on the technical, legal and political situation and issues surrounding the CTBT. It has a US focus, since ratification by the US is widely viewed as the key to finally achieving entry into force.

Recent developments

The importance of the Comprehensive Nuclear Test Ban Treaty (CTBT) on the world stage was brought into sharp focus by the appearance of more than 100 references to it at the Nuclear Non-Proliferation Treaty Review Conference, held at the UN in New York from 27 April to 22 May 2015. These conferences, which occur only every five years, provide important insights into the status of nuclear nonproliferation worldwide and the strengths and weaknesses of this crucial regime. Many countries, in their national statements to the conference, emphasised the importance of bringing the Treaty into force and called out those eight states whose ratification is required for this to occur—the US, Iran, Israel, Egypt, China, India, Pakistan, and North Korea.

Another important event was the CTBT Science and Technology Conference held in Vienna from 22–26 June 2015. This is the latest in a series of such events, held every two years, to report the latest scientific research relevant to the implementation and verification of the CTBT. This work focuses on the four monitoring technologies used by the International Monitoring System (IMS)—seismic, radionuclide, hydroacoustic and infrasound—plus on-site inspection (OSI); which together make up the CTBT's verification regime This latest conference drew over 1,000 scientists from around the world, who presented a large number of formal lectures and more than 300 poster presentations. It was preceded by a three day workshop on a large on-site inspection exercise held in Jordan in November, 2014.[1] The Science and Technology Conference concluded with an 'Academic Forum,' in which professors and other experts discussed their experiences in presenting on the CTBT to students and other audiences.

The gathering was hosted by Lassina Zerbo, Executive Secretary of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). Keynote addresses were given by Naledi Pandor, Minister of Science and Technology of South Africa, Ahmet Uzumcu, Director General of the Organization for the Prohibition of Chemical Weapons and Lord Des Browne, former UK Secretary of Defence and current Vice-Chairman of the Nuclear Threat Initiative. Strong contributions were also made by William Perry, former US Secretary of Defense, Frank Klotz, Administrator of the US National Nuclear Security Administration', Robin Grimes, Chief Scientific Adviser to the UK Foreign and Commonwealth Office and Michael Linhart of the Ministry of Foreign Affairs of Austria, among others.

It is difficult to summarise such a large scientific gathering. Many of the reports will be published in scientific journals and the abstracts are already available.[2] While there were no dramatic scientific headlines, it is fair to say that the overall conclusion is that the techniques for detecting and identifying clandestine nuclear explosions are continuing to improve impressively and there is great interest in the associated science.

Nevertheless, it must be recognised that obstacles to entry-into-force still exist. In particular, in spite of the high priority assigned to US ratification of the treaty by the Obama administration when it came into office in 2009, the two-thirds vote required in the US Senate have yet to be secured. The reasons for this are no doubt partly political, but it should be recognised that more tangible objections are also put forward by reasonable people. An examination of these, in view of the latest developments, could be helpful in clarifying these issues.

One rather unusual aspect of the CTBT debate is how little the arguments against the CTBT have changed over decades, going back even to the Eisenhower and Kennedy administrations of the 1950s and 1960s. In particular, the statements made today in opposition to the Treaty are remarkably similar to those heard in 1999, when the Treaty went down to a rather decisive and surprising defeat in the US Senate. The arguments in favor are also largely the same as those which were, or which should have been, made then. These arguments, while familiar, are strengthened by 16 years of hard work and experience by the CTBTO and the States-Signatories themselves.

Objection #1: the verification regime is not effective enough

This argument has grown steadily more difficult to sustain as the IMS has been developed and operated, and experience with OSI has grown—in particular with the Integrated Field Exercise in Jordan last year (IFE14).[3]

A major milestone was the 2012 report by the US National Academy of Sciences.[4] Briefly, this highly authoritative report concluded that, as of 2012, the size of a nuclear explosion anywhere in the world that could be reliably detected by the IMS is well under 1 kilotonne TNT equivalent. In Asia, Europe and North Africa, the thresholds are substantially better—between 0.09 and 0.22 kilotonne TNT equivalent. This is no accident—the system was designed that way. The detection threshold for underwater explosions is much lower—about 10 tonnes TNT equivalent worldwide, and explosions down to about 1 ton TNT equivalent through the majority of the world's oceans. Regarding OSI, the academy concluded that teams of inspectors investigating a location suspected of having hosted a nuclear test would have a high likelihood of detecting evidence of any explosions greater than about 100 tonnes TNT equivalent.[5,6] Of course, there is very little likelihood that even a modest explosion could go undetected in the atmosphere or space.[7]

The conclusions of the 2012 report by the National Academy of Sciences—which would be even more favorable after three years of further progress—are generally accepted. However, objections persist. One obvious contention is that no one has said that the IMS could reliably detect *all* nuclear explosions down to zero yield. In particular, claims are still made that a state could cheat by carrying out a clandestine explosion in a specially prepared cavity or salt dome, thus attenuating (decoupling) the seismic signal, perhaps by as much as a factor of 70. These claims are based upon very limited test data involving old tests and ignore other factors that would complicate or reveal such efforts. The academy largely dismissed this cheating scenario. Other hypothetical possibilities, such as hiding a small nuclear explosion in conventional mining blasts were also considered and dismissed as unrealistic.

Of course, it is possible that a very small explosion could go undetected. Those familiar with the CTBT verification regime have always understood that. The next question is: 'so what?' How much advantage would be gained by conducting such a test against the substantial risk of being caught? That goes beyond the scope of this paper, but the key point to bear in mind is that the possibility that a state could make undetected advances through very small explosions would be far greater if there were no CTBT.

Scientists have justifiably pointed to the performance of the IMS during the North Korean underground nuclear tests in 2006, 2009 and 2013. An impressive number of seismic stations detected these relatively small explosions, along with some data from radionuclide and infrasound stations. Nevertheless, some critics have objected that North Korea made no attempt to hide their tests and even announced them publicly. This is, of course, true, but that hardly means there is something deficient in the IMS. Another criticism was that the IMS produced no radionuclide detection data during the second North Korean test. Several points can be made about this. First, the radionuclide network was not fully operational, especially with respect to stations close to North Korea. Second, although the lack of radionuclide detections may have been somewhat of a surprise, it was never claimed that all underground tests would vent radionuclides from the underground site of the explosion into the atmosphere—perhaps North Korea was fortunate in this respect or perhaps they showed some skill at containment. Third, if the CTBT were in force and the on-site inspection mechanism invoked at the request of a member state, the excellent location information generated by the IMS would have put inspectors on–site where convincing evidence of a nuclear explosion would almost certainly have been obtained. Satellite imagery also provided good location information on these activities.

One interesting development at the CTBT Science and Technology Conference was speculation that there may have been an additional very small nuclear explosion in the DPRK on 12 May 2010. This had been inferred from data from Chinese seismic stations and an intensive search that produced data from three additional stations which may support that conclusion.[8] This study represents an exemplary case for a suspected CTBT violation which could have prompted an on-site inspection, if the Treaty had been in force.

A key point which is generally not discussed is that the outstanding efforts of the CTBTO, which develops and maintains treaty's verification regime discussed above, are not the only tools in the verification arsenal.[9] The entire world of so-called 'National Technical Means' would be brought to bear to help monitor the CTBT. It is widely known that the US has substantial assets in this realm, but it is certainly not alone. Among these capabilities available to many states are national seismic and radionuclide detection stations not in the IMS, high-resolution satellite imagery, collection of both particulate debris and gases from both the ground and the air, Bhangmeters and electromagnetic pulse detectors on satellites, interferometric synthetic aperture radar and other NTM. The key point is that, the potential cheater knows neither the capabilities nor the location of these systems.

The bottom line on verification is that it is no longer credible to argue that the Treaty does not meet the standard of being effectively verifiable.

Objection #2: the CTBT is not compatible with the need to maintain the nuclear weapon stockpile

The other major argument that has been circulating for decades is the possible need for nuclear weapons states to carry out new nuclear explosive tests to determine the safety and effectiveness of existing stockpiles, or perhaps even to develop new weapons. This argument has been most prominent in the US, but presumably might be of concern to all states with nuclear weapons. The National Academy of Sciences also addressed this important issue in some detail. In summary, the report noted that US plutonium pit lifetimes now are 85–100 years and concluded that a safe, secure and reliable US stockpile can be maintained without explosive testing, provided that certain criteria are met. These criteria had to do with the scientific and engineering workforce, production facilities, stockpile surveillance, among other issues. These safeguards were largely refined and updated versions of those recommended by the 2001 Shalikashvili Report.[10] Similar considerations would presumably apply to any country which felt the need to maintain its stockpile as long as nuclear weapons exist. Another key point is that the Treaty does not prohibit a very wide range of testing of the many components of a nuclear weapon—only the actual nuclear explosion itself—and powerful computer simulations can be brought to bear on this task.

It should be noted that some of the more thoughtful opponents of the Treaty grant that there is no need for testing for the foreseeable future. However, they are reluctant to agree to a prohibition in perpetuity, given that it is impossible to predict future needs and circumstances. This is a valid point, which is why the negotiators of the CTBT thought to include Article IX, which provides for withdrawal under extreme circumstances. The objection used to be made that no country would summon the political will to withdraw from an important arms control treaty. This argument has been demolished by the US withdrawal from the Anti-Ballistic Missile Treaty and Russia's behavior under the Conventional Forces in Europe Treaty.

Objection #3: the CTBT has little to do with nonproliferation

The CTBT is generally understood to be part of the 'grand bargain' in the NPT. In exchange for the fact that the NNWS were giving up the possibility of having nuclear weapons, the five NWS would eventually give up theirs. Prior to the actual elimination of nuclear weapons, the NWS would stop nuclear explosive testing, which was seen as a key way in which existing nuclear weapons were maintained and improved and new ones created. A CTBT was also seen as a necessary environmental step, especially as regards testing in the atmosphere. The path to a prohibition on all testing ran through a series of important, but less ambitious treaties—the 1963 Limited Test Ban Treaty, the 1974 Threshold Test Ban Treaty and the 1976 Peaceful Nuclear Explosions Treaty. The latter two only entered into force in 1990, after major improvements were made to the verification regime. Thus there is clearly a link between the CTBT and nonproliferation. However, in a backwards sort of way, this came to be oversold and misunderstood, at least in the US.

Well-intentioned proponents of the CTBT claimed that it was strictly a nonproliferation measure—that is, it would prevent other states from developing nuclear weapons. This overlooked the fact that the NPT already contained this prohibition for NNWS and, in fact, blocked new nuclear weapons programs at an earlier stage than conducting actual nuclear explosions. Thus a CTBT would add a new constraint on NNWS only in the case of India, Israel and Pakistan, who were not in the NPT. Of course, none of these three have joined the CTBT, which further illustrates the point (North Korea was a Party, but withdrew). The correct understanding was that the main purpose of the CTBT was to stop testing by the NWS. Since this understanding of the real purpose of the CTBT did not seem like a winning one in a skeptical Washington, it was hidden and the emphasis was put on the supposed pain it would place on NNWS. It was also emphasised that it would involve little sacrifice for the US, since this country already had vast testing experience and superior computer simulation capabilities. The fact that it was a fulfillment of a solemn obligation in NPT Article VI and elsewhere, for which payment from the NNWS had already been received, was almost never mentioned in preparing for, or lobbying for ratification of, the CTBT. When India, Pakistan and North Korea acquired nuclear weapons, and it was further revealed to the US Congress and the public that explosive testing was probably not actually necessary to construct a rudimentary nuclear weapon, this aspect of the nonproliferation rationale for the CTBT became vulnerable.

The US did finally come to a more accurate recognition of the purpose of a CTBT, when US Ambassador John Holum made the following statement to the Conference on Disarmament in January, 1996:

> . . . the test ban's 'core value' is to avert an arms race . . . The CTBT will help impede the spread of nuclear weapons. But its great practical impact will also be for arms control—to end development of advanced new weapons and keep military applications from emerging . . . In truth it is and will remain possible to make simple nuclear weapons without nuclear explosive testing. So the CTBT's fundamental effect is less to preclude the acquisition of nuclear weapons as such, which the NPT addresses, than to constrain the advancement of nuclear weapon capabilities by any country.

Unfortunately, this clarification came too late—after the impression had been created that the primary purpose of the CTBT was to prevent the horizontal proliferation of nuclear weapons. The consequence of this serious tactical mistake on the part of advocates for the CTBT and their misunderstanding of history, is that opponents now question how the US will benefit from ratification. Specifically, they may ask whether proponents seriously believe that North Korea will give up its nuclear weapons if the

US ratifies the CTBT. The answer, of course, is 'no'—but no serious proponent of the CTBT has ever claimed that would be the case.

The correct reverse linkage between the CTBT and nonproliferation is clearly seen in considering the indefinite extension of the NPT at the 1995 Review Conference. Reluctant NNWS agreed to this extension on the condition that a CTBT would be completed by 1996. The text was indeed completed on time, but, 19 years later, it has still not entered into force—a clear failure to fulfill this promise. Thus there is a firm linkage between the CTBT and nonproliferation, though not the one put forward as a straw man by opponents.

What the US, or any other Nuclear Weapon State, will get out of the CTBT in the future is the wrong question. The primary benefit to the U.S and other NWS has already been received, and honorable countries should fulfill their promises. The key question of the importance of the link to nonproliferation surely lies with the NNWS themselves. One should ask them whether they see the CTBT as important to nonproliferation and international peace and security. The answer can be found in the official statements of these countries in international fora and especially at the NPT Review Conferences. As noted above, the message was clearly delivered at the most recent of these conferences earlier this year.

Objection #4: what is the definition of a nuclear explosion?

The verification and stockpile reliability arguments against the CTBT have remained largely unchanged for decades. A new technical and legal argument appeared after the CTBT was negotiated. This argument points to the fact that the Treaty does not contain a definition of a 'nuclear explosion', although that is what the central prohibition is all about. At first glance, this does seem like a curious oversight, given the extreme attention given to definitions in other arms control treaties—for example START I contains 124 definitions, New START has 90[11] and the just-released P5 Glossary has definitions of 227 nuclear terms.[12] However, this was not an oversight. The NPT contains no such definition and this has never been a problem. It was decided that crafting a legally and technically precise definition without either creating loopholes or casting doubt on legitimate peaceful activities, such as nuclear power and research reactors, particle accelerators, peaceful research into fusion power, among others, would be too difficult. The US put forward a statement on this subject at the 1975 NPT Review Conference and no objections were raised. No country involved in the negotiations saw the need for such a definition during the CTBT negotiations.

The negotiating record indicates no problem on the issue of what is prohibited and not prohibited under the Treaty. Under customary practice, anything that is not prohibited is allowed. However, in order to assure that there would be no misunderstandings, there were discussions of 'activities not prohibited' during the negotiations. In addition to the 1975 statement noted above, an illustrative list of such activities was included in the US Article-by-Article Analysis submitted to Congress. It was made clear that such activities would not be considered a nuclear explosion, despite the fact that they may result in the release of nuclear energy.[13]

In the early stages of the negotiation, several countries favored allowing small nuclear explosive yields—in effect, defining a nuclear explosion for the purposes of the treaty, as one with a yield greater than a certain number of tonnes TNT equivalent. This approach was rejected by President Clinton in 1995 and all countries agreed that the CTBT would be a zero-yield treaty—'true zero' as the treaty negotiators called it. As an aside, the use of the term 'yield', while easy to understand in popular usage, is not the best formulation from a physics point of view. A more accurate formulation would be that what is prohibited is an explosion that goes supercritical—that is, one that creates a self-sustaining nuclear reaction.

There appears to be no misunderstanding on this point. However, a series of objections have been raised in the US, generally about whether the Russian Federation has the same understanding. These involve obscure statements made long ago by Soviet officials, concerns about tests fully contained in a special chamber (*kolba* in Russian) and the idea that a nuclear explosion with a yield that does not exceed an associated conventional explosion somehow does not count. One should note that all of these would be extremely small and might well go undetected, at least by seismic means, with or without a CTBT.[14]

Another possible 'loophole' related to the use of special containment chambers is the hypothetical status of their use above ground. One might argue that a fully-contained, very small nuclear explosion in a special chamber inside a building would be neither in the atmosphere nor underground and therefore not in any of the four prohibited environments—underground, underwater, in the atmosphere or in outer space. The idea, proposed by some NGOs prior to the negotiations, of creating a CTBT by simply adding 'underground' to the three prohibited environments in the LTBT might have been vulnerable to this obscure interpretation. The Russians did toy with the idea of listing four environments in the Treaty early in the negotiations. When questioned, they assured other negotiators that they were not attempting to create a loophole using such an interpretation. In any case, the CTBT does not list prohibited environments. It prohibits all nuclear explosions, which solves the problem. As an aside, the author did briefly float the option early in the negotiations of saying that, for purposes of the treaty, if an extremely small explosion is fully contained inside a building above ground, it is not a nuclear explosion. This would have solved some of the current objections, but would probably have created others. In any case, a different and better path was taken.

More specifically, concerns have been raised about what Russia may be doing at its test site in Novaya Zemlya. These are questions that can and should be addressed by our Russian colleagues. The issue was addressed in 2009 by Victor Slipchenko, who was the Deputy Chairman of the Russian Delegation at the CTBT negotiations. Responding to questions raised in the US about the Russian position, his public recommendations to the Russian government included the following: 'To confirm at a high level our official position, as made public during the ratification of the treaty by the State Duma in 2001 that in accordance with the CTBT all test explosions of nuclear weapons are banned, including so-called 'hydro-nuclear experiments,' whatever the level of energy release.'[15]

For its part, the US conducts occasional announced 'hydrodynamic' tests underground in Nevada. Although these may involve small amounts of fissile material, they cannot go supercritical and are not prohibited by the Treaty. The unclassified version of the 2015 US Compliance Report addresses the definition issue, noting that the P5 Nuclear Weapon States have each declared a nuclear testing moratorium, but the scope of each moratorium has not been publicly defined. It goes on to say that 'While it is difficult to assess the compliance of a given state with its own moratorium, when the scope or meaning of a moratorium is unclear, US assessments are based on the US position of what constitutes a nuclear explosive testing moratorium. The United States currently defines its own nuclear testing moratorium as a commitment not to conduct 'nuclear explosive' tests.'[16]

One other possible insight into the definition issue is that the P5 issued, at the 2015 NPT Review Conference in New York, a new glossary, in four languages, of 227 nuclear terms.[17] One of these is for the term 'nuclear weapon,' whose definition is 'Weapon assembly that is capable of producing an explosion and massive damage and destruction by the sudden release of energy instantaneously released from self-sustaining nuclear fission and/or fusion.' While this is certainly not intended to be a definition of a 'nuclear explosion,' the reference to a self-sustaining nuclear reaction is instructive.

It is important to remember that the CTBT is not in force. Instead, rules for the current situation are provided by Article 18 of the Vienna Convention on the Law of Treaties, which says that a state which has signed a treaty 'is obliged to refrain from acts which would defeat the 'object and purpose' of a Treaty.'[18] Speaking hypothetically, it might be possible that, depending upon a state's interpretation of that obligation, it might conduct activities under the current legal situation that it would not do once the Treaty is in force.

Conclusion

It is not unprecedented for there to be policy differences between the US and its key Allies, though these are usually kept muted. The situation with the CTBT, however, is really quite unique in that, not only have all the NATO Allies ratified the Treaty, many of them are not shy about emphasising the importance of bringing the Treaty into force. This is basically criticism of the US failure, 19 years after completion of the negotiations (which were led by the US), to ratify. With progress on further constraints and reductions on strategic and tactical nuclear weapons beyond New START apparently blocked for the time being, perhaps it is time for a new push on the CTBT.

The relevance and urgency of the CTBT, at least in the US, were enhanced by a speech given on October 21, 2015 in Washington by Secretary of State John Kerry. He said that 'I am determined that in the months to come, we're going to reopen and re-energize the conversation about the Treaty on Capitol Hill and throughout the nation.' [19] Former Secretary of State George Shultz had earlier remarked that 'Senators might have been right voting against the CTBT some years ago, but they would be right voting for it now.'[20]

The world is waiting for the CTBT to enter into force. While difficult to achieve, this is a moral and legal obligation that needs finally to be fulfilled.

The views expressed are those of the author and do not necessarily reflect the policies of the US Government or Georgetown University. This article is based on a lecture given by the author at the CTBT Science & Technology Conference in Vienna, Austria in June, 2015.

Endnotes

1 Earlier in 2015, a workshop was also held in Israel to consider the outcome of the 2014 on-site inspection exercise in Jordan.

2 *CTBT: Science and Technology Conference 2015 Book of Abstracts*, Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, Vienna, June, 2015.

3 For an account of IFE14, see Jenifer Mackby, 'Special Report: Did Maridia Conduct a Nuclear Test Explosion? On-Site Inspection and the CTBT,' *Arms Control Today*, January/February, 2015; see also 'Major Exercise Tests CTBT Verification Regime,' *Strategic Comments*, International Institute for Strategic Studies (London), December, 2014.

4 *The Comprehensive Nuclear Test Ban: Technical Issues for the United States*, National Academies of Science, 2012, www.nap.edu. For a summary, see 'CTBT: US Scientists Answer Concerns of Opponents,' *Strategic Comments*, International Institute for Strategic Studies (London), 2012.

5 This is contingent on inspection teams having location information of sufficient precision—that is, the event was within the 1,000 square km inspection area limit agreed under the CTBT.

6 For more detailed discussion of on-site inspections under the CTBT, see Edward Ifft, 'On-Site Inspections under the 1996 Comprehensive Nuclear Test Ban Treaty:Modalities, and Technical Considerations' VERTIC Occasional Papers 1 and 2, December, 2009.

7 For the current status of the IMS, see www.ctbto.org.

8 Research by K. Koch, P. Richards, W. Kim and D. Schaff presented at the 2015 S&T Conference.

9 The proper full name of this body is the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization. It is called a preparatory commission since the Treaty is not yet in force. For simplicity, this chapter refers to it as the CTBTO.

10 General (ret.) John M. Shalikashvili, *Findings and Recommendations Concerning the Comprehensive Nuclear Test Ban Treaty*, January, 2001.

11 The Strategic Arms Reduction Treaty (START) was a bilateral treaty on the limitation and reduction of strategic nuclear weapons, between the United States and the Soviet Union in 1991. START expired in 2009, and was succeeded by the New START, which entered into force in 2011.

12 P5 Glossary of Key Nuclear Terms,' China Atomic Energy Press, April, 2015, at www.state.gov/documents/organization/243287.pdf. The Glossary was presented by the five NWS at the 2015 NPT Review Conference.

13 *Article-by-Article Analysis of the Comprehensive Nuclear Test Ban Treaty*, US Department of State, 1996, p. 4.

14 Arguments pro and con can be found in *America's Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States,* William J. Perry, Chairman, James R. Schlesinger, Vice Chairman, 2009.

15 *Russia: Former Envoy Outlines Proposals to help Ratification of Test Ban Treaty,* Moscow Carnegie Center for International Peace, July 24, 2009; See also Victor Slipchenko, 'Russia, Ratification and the CTBT's Entry into Force,' Occasional Paper #3, Verification Research, Training and Information Centre (VERTIC), (London), June, 2010.

16 *Adherence to and Compliance with Arms Control, Nonproliferation and Disarmament Agreements and Commitments*, U. S. Department of State, June 5, 2015.

17 'P5 Glossary of Key Nuclear Terms,' China Atomic Energy Press, April, 2015, at www.state.gov/documents/organization/243287.pdf.

18 *United Nations Convention on the Law of Treaties*, entered into force January 27, 1980.

19 Speech by Secretary of State John Kerry at the US Department of Energy, October 21, 2015.

20 *Ibid*.

CHAPTER 7

Chemical demilitarisation in Syria: an overview

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Background

The main objectives of the Syrian chemical demilitarisation programme, which began in October 2013, were to eradicate Syria's chemical weapons production capabilities and to destroy the stockpile of chemical weapons in the state. This is being achieved by the destruction of chemical weapons production facilities as well as the removal and destruction of approximately 1,330 metric tonnes (MTs) of chemicals and related materials from the Syrian Arab Republic, in accordance with the OPCW Executive Council decisions.[1] This has been an enormous undertaking presenting a host of security and logistical challenges amidst an active conflict.

Chemical weapons production facilities

The Syrian Arab Republic declared 27 chemical weapons production facilities. These included both mobile chemical weapon production units and specialised structures, which were located above and below ground. 24 of these production facilities, including all mobile units, have been destroyed to date, and progress is being made on the destruction of the remaining facilities.

Chemical weapons storage facilities

The Syrian Arab Republic also declared several locations across its territory, where chemical weapons were stored (chemicals stored in bulk form and unfilled munitions). The chemical weapons stored in these locations belonged to Category 1, 2 and 3 chemicals, in accordance with the Chemical Weapon Convention (CWC).[2] The unfilled munitions (Category 3 chemical weapons) were all destroyed inside Syria.

Removal of chemical weapons from Syria

All chemical weapons classed as bulk chemicals (Category 1 and 2 chemical weapons), with the exception of isopropanol, were removed from the Syrian territory and transferred to disposal sites outside of the country.

Table 1 List of assisting CWC states parties for removal programme

State party	Assistance offered
The Russian Federation	■ Equipment and materials needed for removal of the chemicals from Syria. ■ Naval security.
Denmark	■ Maritime transport of chemicals from Syria. ■ Naval protection.
Norway	■ Maritime transport of chemicals from Syria. ■ Naval protection.
China	■ Naval escort.
Finland	■ Chemical weapons emergency-response capabilities.
Italy	■ A port for trans-loading of chemicals to the US ship.
US	■ Destruction technology and full operational support to neutralise the Category 1 chemicals aboard a US vessel at sea.

In accordance with the OPCW Executive Council decision, the majority of the chemical weapons were removed from the Syrian Arab Republic. This required the support of CWC states parties to provide the necessary packing material, as well as vehicles and vessels for road and marine transfers, in accordance with the international dangerous goods transportation code. Through a decision of December 2013, the council welcomed offers made by the parties, which offered logistical support for the removal programme.[3] Table 1 demonstrates the types of assistance provided by CWC states parties to pack and remove the chemical weapons outside of the Syrian Arab Republic.

In total, 181 maritime shipping containers containing declared chemicals were removed from Syria. Out of these 181 containers, 62 were transferred by the Norwegian vessel Taiko.[4] The remaining 119 containers were on board the Danish vessel, Ark Futura. These two marine vessels were provided as in-kind contributions by Norway and Denmark.

- *Category 1 chemical weapons:* the secretariat verified the delivery and destruction of Category 1 chemical weapons in facilities provided by states parties as in-kind contributions and at commercial disposal facilities which were selected through an OPCW tender process. These chemical weapons comprised seven different Schedule 1 chemicals or chemicals used in binary chemical weapons systems. The total weight of declared Category 1 chemical weapons was approximately 1,050 MTs.

This quantity included approximately 130 MTs of isopropanol, which was destroyed in Syria by dilution with water. All Category 1 chemical weapons have been destroyed.

- *Category 2 chemical weapons:* the secretariat verified that approximately 265 MTs of the declared Category 2 chemical weapons were transferred to the facilities that states parties provided as in-kind contributions and at the commercial disposal facilities selected through the OPCW tender process for destruction. These chemicals comprised thirteen different scheduled and non-scheduled chemicals. By mid-November 2015, the secretariat had verified the destruction of 255 MTs (96.2 per cent) of Category 2 chemical weapons, which were transferred outside of Syria. The only remaining Category 2 chemical, which is still going through destruction, is hydrogen fluoride (HF) in Veolia ES Technical Solutions, LLC in the US—in order to ensure that a safe disposal process, the destruction of the HF in this facility was delayed.
- *Rinsates and effluents:* in addition, as part of the removal and destruction program, three types of rinsate (A-Solution, B and BB solution rinsate) were produced in Syria during the repacking of declared chemicals. These rinsates were considered as Schedule 1 chemicals and destroyed accordingly at disposal facilities outside of Syria. Additionally, there were around 300 storage tanks located in several Syrian chemical weapons storage facilities containing residual mustard agent, which was destroyed in Syria between 2013 and early 2014.
- *Category 3 chemical weapons:* the secretariat verified the destruction of approximately 1,200 items of Category 3 chemical weapons, which comprised aerial bombs and missile warheads intended to be filled with chemical weapons across several storage facilities in the Syrian Arab Republic.

Table 2 (below) provides a list of declared chemicals and related materials and their disposal locations.

Maritime operations

Port of embarkation: the Syrian port of Latakia was designated as the port of embarkation. All of the Syrian chemical weapons that were removed were decanted, if required, and then packed into standard maritime shipping containers within the Syrian Chemical Weapon Storage Facilities under verification of OPCW inspectors or by application of remote monitoring measures. These containers, escorted by military convoys, were gradually transferred to Latakia between 5 January and 23 June 2014. The containers were loaded on-board the designated vessels provided by assisting states parties.

Table 2 List of declared chemicals by the Syrian Arab Republic

Chemical weapon category	Chemical	Disposal location
Category 1-Unitary	Sulphur mustard (HD)	Cape Ray-US
Category 1-Binary	DF	Cape Ray-US
	Substance A, Hexamine	Ekokem-Finland
	Substances B and BB	Veolia-UK
	Isopropanol	Syria
Category 2	Phosphorus chlorides and sulphides	Veolia-US
	Hydrogen fluoride	Veolia-US and Mexichem-UK
	Hydrochloric acid	Veolia-UK
	Amines, phosphites and alcohols	Ekokem-Finland
Others	Substance A, B & BB rinsate	Veolia-UK
	Containers with residual mustard	Syria
Category 3	Aerial bombs and missile warheads	Syria
Effluents[5]	Effluent resulted from hydrolysis of DF	Ekokem-Finland
	Effluent resulted from hydrolysis of HD	GEKA-Germany

The two vessels used to transfer Syrian chemical weapons to the ports of disembarkation were Taiko, from Norway, and the Danish Vessel Ark Futura. During the loading operation, the ships docked around 20 times in the port of Latakia. The UN-OPCW joint mission verified the whole operation.

- *Taiko:* the Norwegian vessel was used to upload chemical weapons to be destroyed in two commercial disposal facilities in Finland and the US. Taiko delivered her first consignment, comprising declared Category 1 and 2 chemicals, to the port of Hamina Kotka, Finland, on 21 June 2014. These chemicals were transferred to the commercial chemical disposal facility of Ekokem OY AB. Taiko later sailed to Port Arthur, in the US, where she delivered her second and last consignment comprising of Category 2 chemicals on 9 July 2014. These chemicals were transferred to the Veolia ES Technical Solutions, L.L.C.
- *Ark Futura:* the Danish vessel arrived in the Port of Gioia Tauro, Italy, on 1 July 2014. The OPCW inspection team verified that 224 storage tanks filled with approximately 580 MTs of Methylphosphonyldifluoride (DF) and 15 storage tanks filled

with approximately 20 MTs of sulphur mustard (HD), both declared Category 1 chemicals packed into 78 shipping maritime containers were trans-loaded from Ark Futura to Cape Ray for further destruction in the Field Deployable Hydrolysis System (FDHS) (see section below for technical details). The trans-loading operation was completed within one day in the civilian port of Gioia Tauro with application of extensive safety and security measures by the Italian authorities. Ark Futura continued her trip to Marchwood Military Port in the UK, where her consignment of declared Category 1 and 2 chemicals was delivered on 15–16 July. She completed her mission on 20 July 2014 by delivering her last consignment, which was destined for the Ekokem facility at the port of HaminaKotka.

Together, Taiko and Ark Futura successfully delivered approximately 1,170 MTs of Syrian chemicals into the trans-loading and disembarkation ports in Italy, Finland, the UK and the US. The OPCW inspection teams verified all the trans-loading and delivery of chemicals at the disembarkation ports.

Destruction programme

Following the OPCW Executive Council decision, which set detailed requirements for the destruction of Syrian chemical weapons and Syrian chemical weapons production facilities, the council requested the OPCW Director General to explore possible options to destroy these chemicals in commercial chemical disposal facilities.[6]

The OPCW Director General in an official OPCW Note called for proposals for treatment and disposal of chemicals, effluents, and related packing materials with respect to the destruction of Syrian chemical weapons.[7] This document explained the procedure for selecting the commercial companies to participate in the destruction programme.

Table 3 Syrian chemical weapon destruction-related facilities

Destruction facilities provided by the CWC states parties (in-kind continuation)	Commercial disposal facilities (selected through OPCW tender process
The Cape Ray field deployable hydrolysis system chemical weapons destruction facility, US.	Ekokem Riihimäki waste disposal facility, Finland
Ellesmere Port High Temperature Incinerator (Veolia-UK), UK.	Veolia ES Technical Solutions, L.L.C., US
Mexichem, UK.	
Gesellschft zur Entsorgung von Chemischen Kampfstoffen und Rüstungsaltlasten MBH (GEKA MBH), Germany.	

The OPCW Executive Council later authorised the OPCW Director General to enter into contracts with the qualified commercial chemical disposal facilities for the destruction of certain chemicals and effluents. They also accepted in-kind contributions made by assisting states parties, which sponsored commercial entities to implement the Syrian chemical weapons destruction programme.

Disposal facilities

Facilities provided by states parties

Cape Ray: this is a US owned motor vessel, equipped with the FDHS a transportable, high-throughput modular demilitarisation system designed to render chemical warfare material into compounds not usable as weapons. The system used neutralisation technology to destroy bulk chemical warfare agents and their precursors by mixing and heating with reagents, such as water, sodium hydroxide and sodium hypochlorite to facilitate chemical degradation resulting in a destruction efficiency of greater than 99.9 per cent. The neutralisation process generated effluents in volumes of five to 14 times the volume of the chemical warfare material being treated. The effluent could then be disposed of, in accordance with host-nation environmental laws.

A team of OPCW inspectors aboard the ship monitored and verified all of the destruction activities of uploaded chemicals. These chemicals comprised approximate 580 MTs of DF, a binary precursor for sarin gas, which was completely destroyed by 12 August 2014, and approximately 20 MTs of sulphur mustard, which was destroyed by 18 August 2014. The DF hydrolysis effluent (approximate 5,900 MTs) and HD hydrolysis effluent (approximate 330 MTs) were offloaded at the port of HaminaKotka in Finland and the port of Bremen in Germany, for further disposal in designated disposal facilities.

Ellesmere Port High Temperature Incinerator (Veolia–UK): destruction in this facility was provided through an in-kind contribution by the Government of the UK. The facility agreed to destroy three declared Category 1 chemicals. In addition, another Category 2 chemical weapon—which was originally destined for the US (Veolia ES Technical Solutions, L.L.C.) but as a result of unexpected changes to the shipping schedules, could not be removed on time by Taiko—was added to the disposal portfolio of the facility. All of the chemicals, approximately 180 MTs, were received in the military port of Marchwood and, after initial screening, were gradually transferred to the facility. Destruction of these chemicals was completed by 6 August 2014. The OPCW inspection teams visited the disposal facility regularly to verify the ongoing destruction activities and its consistency with respect to the provisions of the Executive Council Decision.[8]

Mexichem, UK: the facility received approximately seven MTs of a Category 2 chemical, hydrogen fluoride, which was also originally destined for the US (Veolia ES Technical Solutions, L.L.C.). The chemical could not be picked-up on time by Taiko as originally planned because of security circumstances. Mexichem completed destruction of the declared Category 2 chemical by May 2015. The OPCW inspection teams visited the facility regularly, and the OPCW Secretariat received regular briefings on the progress of the destruction process.

Gesellschft zur Entsorgung von Chemischen Kampfstoffen und Rüstungsaltlasten MBH (GEKA MBH), Germany: the facility, through an in-kind contribution by the Federal Republic of Germany, provided its services to destroy effluents resulting from neutralisation of sulphur mustard on-board the Cape Ray. The facility received approximately 330 MTs of effluent, which was completely disposed of by March 2015 through incineration at high temperatures. The on-site verification activities at this facility were governed by the decision of the OPCW Executive Council.[9]

Facilities selected as part of the OPCW tender process

Ekokem Riihimäki Waste Disposal Facility, Finland: destruction in this facility was governed through a commercial contract concluded with the OPCW. The company was selected through a tender process, in order to destroy two Category 1 and eight Category 2 chemicals. Approximately 320 MTs of declared Category 1 and 2 chemicals, in two consignments were delivered to Ekokem OY AB on 21 June and 20 July 2014. By the end of October 2014, the facility disposed of 100 per cent of its Category 1 and 2 chemicals.

OPCW inspection teams visited the facility regularly until the completion of the destruction programme. The inspection teams verified that destruction activities were consistent with the provisions of the OPCW Executive Council decision and the commercial contract.[10]

The main technology used for destruction of the Category 1 and 2 chemical weapons was incineration in a high temperature rotary kiln. This method produced a destruction efficiency of greater than 99.99 per cent.

Furthermore, and as part of the commercial contract, the facility received 5,867 MTs of DF hydrolysis effluents to be destroyed over a period of 300 days (until June 2015). By the end of June 2015, the facility disposed of 100 per cent of these effluents.

Veolia ES Technical Solutions, L.L.C.: the facility received an approximate 60 MTs of Category 2 chemicals, in the form of four different inorganic chemicals. By mid-November 2015, around 84.3 per cent of chemicals had been destroyed. There are still technical challenges for destruction of one of the declared chemicals, hydrogen fluoride, while around 60 per cent of the HF has already been destroyed, the remaining chemical will be destroyed during 2015 and the beginning of 2016. The facility has been inspected regularly by the OPCW inspection teams to ensure that the commercial contract has been followed as well as provisions of the OPCW Executive Council.[11]

Conclusion

Removal and destruction of Syrian chemical weapons has been a great achievement for the OPCW. This was accomplished by the dedication and commitment of Technical Secretariat staff with direct support of the CWC states parties. This operation was an excellent example of 'Working Together for A World Free of Chemical Weapons'.

Endnotes

1 Contained in EC-M-34/DEC.1, 15 November 2013, EC-M-36/DEC.2, 17 December 2013, and EC-M-38/DEC.1, 30 January 2014.

2 Category 1 chemical weapons are chemical weapons on the basis of the CWC Schedule 1 chemicals and their parts and components (paragraph 16, Section C, Part IV (A), Verification Annex, CWC). This definition also includes all the chemicals used in any binary chemical weapon system (i.e. Hexamine). Category 2 chemical weapons are chemical weapons on the basis of all other chemicals and their parts and components (paragraph 16, Section C, Part IV (A), Verification Annex, CWC). Category 3 chemical weapons are unfilled munitions and devices, and equipment specifically designed for use directly in connection with employment of chemical weapons (paragraph 16, Section C, Part IV (A), Verification Annex, CWC).

3 EC-M-36/DEC.2, dated 17 December 2013

4 This number only refers to containers with declared chemical weapons and not containers with related material or solid wastes.

5 As a result of destruction of two Category 1 chemicals in the Cape Ray Field deployable Hydrolysis System Chemical Weapons Destruction Facility, US, two types of effluents from hydrolysis of Methyl-phosphonyldifluroide (DF) and sulphur mustard (HD) were produced.

6 EC-M-34/DEC.1, dated 15 November 2013

7 EC-M-36/DG.4, dated 16 December 2013.

8 EC-76/DEC.5, dated 11 July 2014

9 EC-M-40/DEC.1, dated 29 April 2014

10 EC-75/DEC.4, dated 5 March 2014

11 EC-M-42/Dec.2, dated 17 June 2014

CHAPTER 8

The Biological Weapons Convention: implementing legislation and compliance

Angela Woodward

A VERTIC yearbook would not be complete without a chapter on biological weapons and the 1972 Biological Weapons Convention (BWC).[1] The biological weapons-related chapters in previous VERTIC yearbooks focused primarily on verification.[2] They initially addressed the impact of the absence of verification measures, the need to strengthen the convention through verification measures, and updates on the United Kingdom's practice inspections. Later they considered progress, setbacks and finally the spectacular disintegration of the negotiations for a legally binding agreement—the 'verification protocol'—which would have provided verification and compliance monitoring measures for the convention in 2001.

The challenge of how to resolve the verification conundrum in the BWC remains, particularly as exponential developments in science and technology increase the risks of both intentional and inadvertent non-compliance with the convention—such as the deliberate or coincidental development of novel biowarfare agents and related delivery systems. The BWC inter-Review Conference 'intersessional' meeting process has, since 2002, successfully evaded calls from various quarters for states parties to collectively and explicitly deal with this verification challenge, most recently at the 2015 Meeting of Experts. However the issue will undoubtedly resurface at the convention's Eighth Review Conference in late 2016, as a sizeable number of states parties continue to call for the convention to be strengthened through an additional, legally-binding agreement on verification measures and reiterate their view that compliance can only be determined through verification.

In the absence of agreement to deal with the verification challenge, certain states have mooted a handful of proposals[3] in the BWC intersessional process on additional means for demonstrating compliance and enhancing assurance of compliance with the convention. Along with proposals raised by civil society researchers,[4] these are percolating in the Track I and Track II spheres. It is fair to say that there are divergent opinions on pursuing further confidence-building measures over verification and compliance monitoring measures. However these proposals warrant serious consideration at the Review Conference as well as by states parties that wish to contest the rather complacent attitude toward compliance in BWC diplomacy by taking on more effective transparency and confidence-building measures unilaterally and by supporting a more systematic and coordinated process for analysing compliance, at least until states parties can collectively revisit verification options.

VERTIC is a non-governmental organisation with longstanding involvement in biological weapons diplomacy and related policy research. Over the years, VERTIC staff have analyzed the BWC verification negotiations, proposed alternative confidence-building, transparency and other measures that could help to alleviate its verification lacunae and, more recently, developed legislative tools to assist states to adhere to the convention and implement it. This legislative work was prompted by BWC states parties renewed interest in national implementation as a result of the intersessional process. VERTIC's legislative assistance work subsequently morphed into a programme providing legislative implementation assistance globally not just for the BWC, but also other international legal instruments that give rise to domestic legislative implementation obligations on chemical, biological, radiological and nuclear (CBRN) weapons non-proliferation. In particular, this work comprehensively addresses legislative requirements for UN Security Council Resolution (UNSCR) 1540 (adopted in 2004) on the non-proliferation of weapons of mass destruction to non-state actors. This expansion was similarly prompted by recognition of the need for tailored legislative assistance provision to help states to fulfil complex implementation requirements. VERTIC is now a 'one-stop shop' for states looking to redress shortfalls across their CBRN national legislation in a harmonised manner.[5] Given the similarities in national implementation requirements across these international legal instruments, it is efficient for states to take a coordinated approach to identifying and rectifying any deficiencies in their national legal order, especially when they have scarce resources to commit to this challenge.

So it is timely in this VERTIC yearbook, which now specifically includes implementation alongside verification in its purview, to reflect on the issue of national implementation of the convention through national measures. As indicated above, this chapter focuses on one form of national implementing measures—legislative measures—as it relates to compliance with the convention. It acknowledges the requirement for a wider suite of national implementing measures, including administrative and judicial measures as well as other actions and activities such as awareness-raising and training, to facilitate compliance—but focuses specifically on the relationship between implementing legislation and compliance. This is an interesting issue as states parties are discussing proposals to boost transparency and confidence-building about compliance, and on means to enhance assurance of compliance, all of which have the consideration of national implementing legislation as a core component. Any resulting process—whether engaged in by a collective of states parties between themselves on a voluntary basis, or applied to all states parties by means of collective agreement—will need to encompass all of the BWC obligations that require implementation through domestic legislation and also recognise that the complexity of the legislative framework will necessarily differ for each state, depending on its particular situation and characteristics with regard to the convention.

This chapter is intended to provide some food-for-thought for avid followers of BWC diplomacy on an important but somewhat niche issue—legislation and compliance. It also aims to provide a taste of some of the discussions on 'compliance assurance' for those who dip in and out of BWC issues.

The chapter begins by outlining the requirement to take national implementing measures under the BWC. It notes why national legislation, in particular, is required as part of those measures and which treaty obligations typically require implementation through legislation. Next, it discusses the relationship between implementing legislation and compliance, in generic terms, and highlights the need for different models of legislative compliance in the BWC context. Then it considers states parties' views, collectively and individually, on the relationship between legislation and compliance, and the role of legislation in proposed compliance assurance processes. It concludes with some thoughts on the impact on the treaty regime of states parties' treatment of the legislative compliance issue.

National implementation through national legislation

The binding obligation on BWC states parties to put in place national implementing measures for the convention is abundantly clear, as Article IV requires states parties to take 'any necessary measures' to give effect to the convention at the national level, in accordance with their constitutional processes.[6]

States parties with a common law legal tradition (which maintain that international and national legal systems are distinct) are obliged to transform their obligations under an international legal instrument[7] into national law (through legislation), as well as take any other appropriate measures. States with a civil law system (which maintain that international and national law form a single legal order), may be able to incorporate treaty obligations automatically into national law on entry into force (these are described as 'self-executing' treaties) if this is permitted by their Constitution. However, the BWC is not considered to be a self-executing treaty.[8] The complexity of the activities required to fulfil the convention's obligations to prohibit and prevent biological weapons are such that national legislation, in addition to other forms of national measures, is also essential for civil law states parties.

The requirement for domestic legislation, as a core component of such national implementing measures has been examined extensively in other publications.[9] In essence, domestic legislation is necessary to prohibit and prevent the development, production, stockpiling, acquisition or retention of the agents, toxins, weapons, equipment and means of delivery specified in Article I. This requires penal legislation to establish penalties and offences for violations, including for biological weapons *use*, which is implicitly prohibited under the convention (and confirmed explicitly by states parties at Review Conferences). Legislation is also required to give effect to obligations on transfer controls (Article III); on consultation and cooperation (Article V), on cooperation with a UN Security Council investigation (Article VI(2)); as well as the Confidence-Building Measure process (to facilitate the collection and submission of national information in CBM returns, which may require explicit authority by means of legislation). The CBM process was instituted at the Second Review Conference in 1986 as a means to strengthen the authority of the convention and enhance confidence in its implementation. States parties' participation in the process is intended to 'prevent or reduce the occurrence of ambiguities, doubts and suspicions, and in order to improve international co-operation in the field of peaceful bacteriological (biological) activities'.[10] It entails collating and submitting information on a series of forms by 15 April each year, for circulation among states parties only.[11] If a state already possesses biological weapons, as defined in Article I, then it may also require legislative measures to complete disarmament actions.[12]

From an international law perspective, then, all BWC states parties need to adopt and enforce national legislation, in addition to other necessary national measures, to give effect to the convention. States parties have confirmed this understanding, by collectively noting the importance of legislative (and other measures) in enhancing domestic compliance.[13] They also collectively agreed at the Seventh Review Conference that enacting and implementing legislation, especially penal legislation (as well as administrative, judicial and other measures), which are designed to enhance domestic implementation of the convention's core obligations, establish legal jurisdiction, and ensure biosafety and biosecurity, would 'strengthen the effectiveness of convention'. They regularly call on each other to enact and implement such measures.[14] More recently, they also collectively specified that laws and regulations are key elements of an effective national export control system.[15]

The requirement for legislation as part of national implementation measures is also supported by state practice. A majority of states parties has taken the floor during the standing agenda item on strengthening national implementation during the BWC intersessional process to document and describe their national measures—particularly legislation—as part of their overall national implementation framework. Moreover, those who have not taken the opportunity to speak to the status of their implementing legislation do not claim that they are under no such legislative obligation.

The relationship between legislation and compliance

Despite this requirement for national implementing legislation, and states parties' collective understanding and agreement that national legislation is an essential element of the national implementing measures required under Article IV, there is a reluctance among some states parties to discuss or describe implementing legislation as a compliance issue in BWC diplomacy. Legislation is regularly mentioned as having an important role in generating confidence in states parties' compliance and in states parties' *commitment* to compliance. Certainly, legislation is a demonstration of a commitment to compliance, particularly if it is appropriate and effective, and is widely promulgated among stakeholders and routinely enforced. However, the adoption and enforcement of implementing legislation is not just a requirement for effective BWC implementation, as discussed above, or a demonstration of a commitment to compliance. It facilitates compliance. Without it, or enough of it on a range of legal issues, states cannot give effect to the convention's prohibitions. They could not investigate and prosecute biological weapons crimes or breaches of strategic trade controls or biosafety and biosecurity regimens, for example.

It is well recognised that incomplete legislative implementation in a state party is likely due to insufficient resources, the need for technical assistance and/or competing national priorities. For these states, transparency about their intentions with regard to ensuring effective legislative implementation (now and into the future) helps to assuage any concerns about this aspect of compliance.

This hesitancy by some states to discuss implementing legislation as a compliance issue, and therefore to equate an absence of appropriate and effective national implementing legislation with non-compliance, does not occur solely in the BWC context. It also occurs in other treaty regimes, especially those on highly politicised issues. In those instances, obligations pertaining to national implementing measures and compliance may be treated as separate issues (albeit equally important), or non-implementation of required domestic measures may be treated as a technicality; 'technical' non-compliance, at least anecdotally. The distinction has the effect of downplaying the non-compliance and implying that the non-compliance is not serious; that the state is not at fault (no matter how long the situation persists); and does not intend to be in non-compliance—which is almost always the case in practice. Crucially, non-implementation is distinguished from other forms of non-compliance that would warrant the use of compliance and enforcement mechanisms, particularly deliberate breaches of core prohibitions.[16] This is in contrast to non-compliance in the form of a deliberate, gross treaty violation ('substantive' non-compliance) which, in the non-proliferation and disarmament context, could put the violating state party at a military or other advantage and which, whether left as a lingering suspicion or allegation, or confirmed through verification, has more serious repercussions for the strength of the treaty regime.

How states parties choose to respond to suspected or proved non-compliance, collectively and individually, as well as how they choose to describe it, is up to them. The distinction between these two types of non-compliance—non-implementation (a technicality) and a gross violation (substantive non-compliance)—is warranted. They each require a different response from states parties to ensure that compliance is achieved. Non-compliance through non-implementation may have serious implications, such as if it exposes the state to being a safe haven for bioterrorism, and the state may be at least partially at fault if it has not taken up repeated offers of necessary assistance. However, as intent is a major factor in distinguishing these different forms of non-compliance, it should not be problematic to refer to complete or partial non-implementation as non-compliance, as long as other states parties respond appropriately, such as by offering and providing necessary technical and other assistance, including through expert partners, and the affected state takes steps to remedy the situation as quickly as possible.

In the BWC context, all states parties have some pre-existing legislation that gives effect to at least some of their obligations under the convention. However, this ranges from some very basic penal provisions that could be applied to punish certain biological weapons-related crimes (at least, biological weapons use where it results in personal injury or death) in some countries, right through to states that have a patchwork of uncoordinated laws on related issues that are not harmonised, or do not have an effective oversight structure, and which still leave undesirable gaps. Pre-existing legislation that was adopted to give effect to other, but related, international obligations or policy concerns will go some way to meeting BWC obligations but not necessarily effectively or comprehensively, and they may be outdated in light of revised applicable standards.

So what would compliance with the BWC's legislative obligation look like? Much like the question frequently posed of verification—'how much is enough?'[17] how much legislation is required? The scope and complexity of national implementing legislation necessary to give effect to the BWC will vary between states parties. That much everyone agrees on. It will depend on the state's specific situation and characteristics, including factors such as:

- whether the state operates a biodefence programme;
- the size (or even, the existence) of a biological science research sector or biotech industry and associated facilities;
- whether it is host to one or more biosafety level 4 (or equivalent) laboratories (which can work with the most dangerous biological agents);[18]

- the extent of domestic and cross-border transfers of controlled agents, toxins, equipment and technologies;[19] and
- arguably, its risk of being used as a safe haven for bioterrorism and its risks of other biological weapons-related crimes.

Asking the converse question might be helpful in identifying what aspects of implementation should be addressed by legislation (either primary legislation—laws—or other legislative instruments such as regulations). When might a lack of effective implementing legislation for the BWC so impair the state's ability to fulfil its obligations, depending on its specific situation under the convention, that it could constitute non-compliance? Or put another way, can the state effectively prevent and prohibit biological weapons—or not? It can be helpful to pose some questions of the existing legislation to test how it works. If an exercise to hypothetically test the legal framework determines that existing laws are insufficient to address a plausible scenario, it will help in identifying what additional provisions are needed.

At the most basic level, if any state party is not able to undertake the following activities under existing legal authority, then it cannot effectively fulfil its legislative obligations under the convention:

- investigate and prosecute biological weapons crimes (development, manufacture, production, acquisition, stockpiling, possession, retention, transfer, transport and use etc.);
- investigate and prosecute related activities (assistance, encouragement, inducement, financing, accomplices etc.);
- establish jurisdiction over such offences committed in its territory or under its jurisdiction or control anywhere; establish jurisdiction over such offences committed by natural or legal persons possessing its nationality;
- control transfers of dangerous biological agents and toxins, and related equipment and technology, or non-controlled biological agents and toxins that are suspected of being misused for illegal purposes (through a catch-all clause) (even if this is just a framework structure with offences and penalties, which can be easily amended later in response to specific risks);
- destroy or divert to peaceful uses any of the agents, toxins, weapons, equipment or means of delivery specified in Article I (disarmament, if this is applicable to the state).

It follows that states with more than a basic capability in the relevant scientific industries will require more complex national implementation measures, particularly legislative measures. Most BWC states parties would fall in this category. If such a state party is not able to undertake the following additional activities under existing legal authority, then it likely cannot effectively fulfil its legislative obligations under the convention:

- account for, secure and physically protect dangerous biological agents and toxins;
- ensure the physical protection of relevant facilities;
- authorise permitted activities involving dangerous biological agents or toxins (by means of licensing and registration) and require personnel reliability checks for persons working with such agents or toxins;
- co-operate and co-ordinate with public health officials and other agencies in the event of an incident involving dangerous biological agents and toxins;
- co-operate with and assist other law enforcement agencies in the event of an incident involving dangerous biological agents and toxins;
- maintain continuous oversight of national implementation, generally, and review and update national implementation policy and measures appropriately (such as through a national interagency body); and
- collate and submit information required under the Confidence-Building Measure returns.

These lists are indicative, not definitive or exhaustive, of legislative compliance requirements. Certain domestic factors, which help to form a picture of a state's specific situation concerning implementation, will need to be taken into account in determining the requirements for compliance with legislative implementation. As the various proposals on compliance assurance acknowledge, the status of legislative (and other) measures needs to be weighed up with other implementation activities to form an overall assessment of compliance.

States parties' views

States parties have conducted meaningful discussions on what might constitute compliance with the convention recently.[20] More teasing out of what states understand to constitute compliance with the convention will inform further consideration of appropriate compliance assurance, monitoring and verification techniques. As part of these discussions, some states parties have specified that legislation is an essential element of national implementation and discuss it in compliance terms. Working papers by the United Kingdom, Australia, Switzerland and the United States in the current intersessional process acknowledge that, while there is no single checklist of actions or omissions that clearly indicate compliance or non-compliance with the convention, there are particular indicators of compliance and non-compliance which can be considered together in making a compliance assessment. Consistently, the adoption and enforcement of legislation, especially penal legislation, and national export control legislation are listed as indicators of compliance.[21]

The United Kingdom and Switzerland make a clear distinction 'between compliance with Articles I and II on the one hand and Articles III and IV on the other'. [22] That is, they distinguish between states parties' compliance with the core biological weapons prohibitions and the requirement to disarm biological weapons programmes under Articles I and II—and their comprehensive national implementation obligations under Articles III and IV. The United Kingdom's working paper acknowledged that '[f]ailure to enact comprehensive implementing legislation places a State Party formally in non-compliance with its Article IV obligations. However, this is not in the same category as non-compliance with Article I's core prohibitions . . . '.[23] These papers do not describe this distinction along the lines of non-implementation (or technical) non-compliance and gross violation (substantive) non-compliance as described above; but it is capable of being inferred. The papers do not specify the implications of this distinction, although they do recognise, along with the paper by the United States, that there is a need to be realistic about the implementation burden facing certain states when making compliance judgments. They suggest that for states so burdened, an absence of necessary national implementing measures (including legislation) should not be read as an indicator of an intention not to comply with the core treaty prohibitions, and (in the US working paper) should not necessarily even be considered in a compliance judgment.[24] However, the United Kingdom noted that 'a reluctance to enact and enforce national legislation despite repeated offers of assistance' is one (of many) possible indicators of concern about a state party's attitude to compliance. This increases the importance of states parties sharing information on their intent with regard to their legislative implementation obligations.

As noted above, legislative implementation is an element of a number of proposals for means to enhance assurance in compliance with the BWC, essentially through providing information on legislative measures enacted and on their enforcement, through additional transparency and confidence-building measures (TCBMs). Such proposals do not envisage sanctions or enforcement; rather, transparency is intended to provide information on implementation that could assure other states parties that this obligations is being fulfilled, and create an environment for cooperation and assistance to facilitate strengthened implementation and compliance.

However, certain other states parties maintain that assessments of compliance with national implementing measure (including legislation) obligations should not be conducted as a separate activity to assessments of implementation of all aspects of the convention (that is, including those implementation obligations that do not necessitate domestic implementing legislation). These states consider that proposals for additional confidence-building measure tools do not address all aspects of BWC implementation and that they can only have a transparency and confidence-building role, as they do not have the same status as a declaration and cannot be used in a process to formally assess compliance.[25] For example, a statement by Iran on behalf of the Non-Aligned Movement specified that, in the BWC context, 'the assurance of compliance with the convention's provisions has to be undertaken collectively through appropriate multilateral verification arrangements'.[26]

In contrast to the minimalist approach to demonstrating compliance with national implementing requirements that is taken in the current CBM process ('yes/no' responses to four questions), national legislation is the central component in the 'Compliance Assessment' process proposed by Canada. Under this more expansive approach, states parties would prepare and submit an initial detailed submission to the BWC Implementation Support Unit, and thereafter submit annual updates, on their national implementing legislation and regulations as well as their overall national implementation programme, including descriptions of how the laws work in practice and how they are enforced, including helpful flowcharts.[27] The process is intended to demonstrate a commitment to national implementation and compliance, and could result in 'an assessment of compliance of the national program to the BTWC'.[28]

Another proposal similarly recommends instituting additional TCBMs, that could be undertaken unilaterally, bilaterally or multilaterally, to provide reassurance of compliance in addition to the existing CBM process. These would entail comprehensive reporting on, inter alia, domestic legislation, including penal laws; transfer control regulations; and national biosecurity measures.[29] This proposal specifically highlights a role for regional cooperative assistance in undertaking such measures, which in itself would have a compliance assurance function.

A related proposal suggests further consideration of what sort of information would help prevent or reduce the occurrence of ambiguities, doubts and suspicions about compliance under the existing CBM process, as part of an overhaul intended to improve participation rates.[30] The proposal notes that 'transparency around capabilities and intentions lies at the heart of assessing compliance and promoting mutual confidence in the BTWC context'. In legislative implementation terms, the current CBM returns do not enable effective reporting of this crucial aspect of capability—or intentions, for that matter—without a more intensive documentation of national legislative and regulatory systems, along the lines of that proposed by Canada.

'Peer review' proposals go one step further, by incorporating a review process for information submitted through a confidence-building measure information exchange.

France's peer review proposal is intended both to generate confidence in compliance (including through in-country transparency visits) and facilitate the provision of necessary assistance to rectify any deficiencies. It suggests a modular approach, with the first module concentrating on national legislation and regulations, and the possibility of adding further modules as desired. The BENELUX countries (Belgium, Netherlands and Luxembourg) have taken up France's call for peer review trials by announcing that they will conduct a peer review exercise among themselves and contribute their findings to the Eighth Review Conference.[31] This peer review process suggests using a 'questionnaire tool' that applies objective principles, criteria and standards for implementing legislation to gather the baseline information for review.

VERTIC has already developed a survey template on national implementing measures for the BWC and related requirements of UNSCR 1540, which it uses in its legislative assistance work to identify existing relevant legislative and other provisions. As with France's proposed questionnaire tool, VERTIC's surveys are not compliance assessments; rather, they identify what measures are in place against a comprehensive range of implementation obligations which the respective state can use to assess its own compliance against its specific circumstances and, aided by VERTIC's technical expertise, rectify whichever gaps it has identified as it sees fit.

A civil society proposal extends the peer review process further by calling for declarations (reaffirming their commitment to the convention's core prohibitions), in addition to documentation (through reporting on national implementation measures) and demonstration (through regular visits), in a new '3D Bio' initiative. This proposal is intended specifically for those states parties with biological defence programmes and biosafety level 4 (or equivalent) laboratories.[32]

Impact on the treaty regime

A perception that legislative compliance with the BWC is largely a procedural issue, however widely held, belies its importance in preventing biological weapons and can result in some unintended negative consequences for the BWC regime, not least making it more difficult to prioritise BWC implementation at the national policy level. Legislatures always have more bills proposed than time available to consider them. It takes a committed government, and national champions willing to shepherd it through complex national policy processes and ensure full inter-agency coordination and co-operation, to undertake the process, overcome the hurdles along the way and enact legislation in anything less than a couple of years. More complex legislation and regulatory frameworks, such as to establish national export controls or biosecurity regimes, can take even longer. In particular, without an explicit requirement for a national oversight structure, such as the Chemical Weapons convention requires, it can prove difficult to requisition a budget line to undertake national implementation oversight and enforcement functions.

For as long as the consideration of compliance continues to feature as part of a confidence-building measure process in the BWC regime (in addition to states parties individual assessments of each others' compliance), rather than a more sophisticated, systematic compliance determination process of the type that necessitates an international verification organisation, then states parties may feel justified in maintaining the convention's nascent secretariat as an administrative office, with skeletal staffing and resources. That will continue to constrict the regime's outreach activities and its ability to centralise the matching of offers and requests for assistance, including with national implementation requirements, long after the functional (but time-bound) equivalent structure for the related obligations in UNSCR 1540—the 1540 Group of Experts—expires. The BWC regime needs to be strengthened, to an appropriate scale, to assist states parties to keep up with the risks of intentional and inadvertent non-compliance through the rapid developments in related science and technology.

Endnotes

1 Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction. The treaty was opened for signature on 10 April 1972 and entered into force on 26 March 1975.

2 These include chapters by Erhard Geissler (1991, 1992), Barbara Hatch Rosenburg (1993, 1994), John Walker (1994), Robert Mathews (1995, 1996) Nicholas Sims (2000), Marie Chevrier (2001), Jenni Rissanen (2002) and Jez Littlewood (2003).

3 For example, calls for additional information to be included in the annual confidence-building measure returns (United Kingdom); a compliance assessment process (Canada, Czech Republic and Switzerland); a peer review mechanism (France); and a bio-transparency and openness initiative (United States): see 'BWC compliance - a conceptual discussion: preliminary views by Australia', submitted by Australia, BWC/MSP/2013/MX/WP.2, 29 July 2013, p. 3.

4 For example, UNIDIR's study on peer review mechanisms, 'A peer-review mechanism for the Biological and Toxin Weapons Convention', submitted by France, BWC/MSP/2012/WP.12, 18 December 2012, which elaborates on the concept that France submitted in its earlier working paper to the Seventh Review Conference in 2011. See also Filippa Lentzos, '3D Bio: declare, document and demonstrate', *Non-Proliferation Papers*, No. 45, April 2015, EU Non-Proliferation Consortium.

5 The author acknowledges the work of her VERTIC staff colleagues, past and present, on this programme: Yasemin Balci, Sonia Drobysz, Rocío Escauriaza Leal, Bilqees Esmail and Scott Spence. All views expressed in this paper, however, are her own.

6 For more description on the Article IV obligation see Angela Woodward, 'The Biological Weapons Convention and UNSCR 1540', *Global non-proliferation and counter-terrorism: the impact of UNSCR 1540*, Olivia Bosch and Peter van Ham (editors), Brookings Press, Chatham House, and Clingendael, 2007, pp. 100–101.

7 In the context of this chapter, a convention, but equally a treaty, protocol or other form of legal agreement between states; the nomenclature is an irrelevant distinction.

8 See Nicholas Sims, 'Strengthening structures for the Biological and Toxin Weapons Convention: options for remedying the institutional deficit', *Toward a stronger BTWC*, Disarmament Forum No. 3, 2006. UNIDIR: Geneva, 2006, p. 18; and Treasa Dunworth, Robert J. Mathews and Timothy L.H. McCormack, 'National implementation of the Biological Weapons Convention', *Journal of Conflict & Security Law* (2006), Vol. 11 No. 1, pp. 98–99. This has also been formally acknowledged collectively by states parties through Review Conference outcomes calling for all states parties to adopt legislative, administrative, judicial and other measures, including penal legislation; see *Additional agreements reached by previous Review Conferences relating to each article of the Convention*, Prepared by the BWC Implementation Support Unit, UN Office for Disarmament Affairs, Geneva, Switzerland, February 2012, Section VI, [on] Article IV, 2. On legislative, regulatory and administrative measures, p. 7.

9 In particular, see Treasa Dunworth, Robert J. Mathews and Timothy L.H. McCormack, 'National implementation of the Biological Weapons Convention', *Journal of Conflict & Security Law* (2006), Vol. 11 No. 1, pp. 993–118.

10 'History and operation of the confidence-building measures', BWC/CONF.VII/INF.1, 28 September 2011, p. 2.

11 The current iteration of the forms requests information and declarations as follows: exchange of data on research centres and laboratories (CBM A, Part 1); exchange of information on national biological defence research and development programmes (CBM A, Part 2); exchange of information on outbreaks of infectious diseases and similar occurrences caused by toxins (CBM B); encouragement of publication of results and promotion of use of knowledge (CBM C); (CBM D has been deleted); declaration of legislation, regulations and other measures (CBM E); declaration of past activities in offensive and/or defensive biological research and development programmes (CBM F); declaration of vaccine production facilities (CBM G). The CBMs were revised at the Third Review Conference (in 1991), Sixth Review Conference (procedural changes only, in 2006) and Seventh Review Conference (in 2011). For more information, see: 'History and operation of the confidence-building measures', BWC/CONF.VII/INF.1, 28 September 2011; 'Final Document of the Seventh Review Conference', BWC/CONF.VII/7, 13 January 2012.

12 These legislative requirements are comprehensively examined in Treasa Dunworth, Robert J. Mathews and Timothy L.H. McCormack, 'National implementation of the Biological Weapons Convention', *Journal of Conflict & Security Law* (2006), Vol. 11 No. 1, pp. 93–118.

13 *Additional agreements reached by previous Review Conferences relating to each article of the Convention*, Prepared by the BWC Implementation Support Unit, UN Office for Disarmament Affairs, Geneva, Switzerland, February 2012, Section VI, [on] Article IV, 2. On legislative, regulatory and administrative measures, p. 7.

14 Most recently at the BWC Seventh Review Conference: *Final Document*, BWC/CONF.VII/7, 13 January 2012, Article IV, p. 11.

15 For example, in the 'Synthesis of considerations, lessons, perspectives, recommendations, conclusions and proposals drawn from the presentations, statements, working papers and interventions on the topics under discussion at the [2015] Meeting of Experts', submitted by the Chairman, BWC/MSP/2015/L.1, 5 November 2015, p. 8, which does not have binding status, as one might infer from its tortuous title.

16 On non-implementation as non-compliance, see Peter Van den Bossche, 'In search of remedies for non-compliance: the experience of the European Community', 3 *Maastricht J. Eur. & Comp. Law* 371, 1996, pp. 372–374.

17 This is also the title of a seminal work on arms control verification; see Allan S. Krass, *Verification: how much is enough?*, SIPRI. Taylor & Francis: London, 1985, books.sipri.org/product_info?c_product_id=234

18 'Biosafety Level 4 is required for work with dangerous and exotic agents that pose a high individual risk of aerosol-transmitted laboratory infections and life-threatening disease that is frequently fatal, for which there are no vaccines or treatments, or a related agent with unknown risk of transmission'; US Centres for Disease Control, *Biosafety in Microbiological and Biomedical Laboratories*, 5th Edition, Section IV – Laboratory Biosafety Level Criteria, www.cdc.gov/biosafety/publications/bmbl5/bmbl5_sect_iv.pdf

19 Such as those specified in the Australia Group control lists, the European Union's regime for the control of exports, transfers, brokering and transit of dual-use items, or the United States government's 'Select Agents and Toxins' list.

20 Recent discussions were prompted by working papers to BWC treaty meetings, in particular see: 'Proposal for a working group to address compliance issues', submitted by Australia, Japan and New Zealand, BWC/CONF.VII/WP.11, 19 October 2011; and 'We need to talk about compliance', submitted by Australia, Canada, Japan, New Zealand and Switzerland, BWC/MSP/2012/WP.11, 12 December 2012.

21 For example, see 'We need to talk about compliance: a response to BWC/MSP/2012/WP.11', BWC/MSP/2013/MX/WP.1, 2 July 2013, submitted by the United Kingdom of Great Britain and Northern Ireland; 'BWC compliance – a conceptual discussion: preliminary views by Australia', submitted by Australia, BWC/MSP/2013/MX/WP.2, 29 July 2013; 'Compliance with the BWC: preliminary considerations by Switzerland', submitted by Switzerland, BWC/MSP/2013/MX/WP.12, 9 August 2013; A response to BWC/MSP/2012/WP.11: 'We need to talk about compliance', submitted by the United States, BWC/MSP/2014/MX/WP.10, 4 August 2014 (this paper implies that legislation, among other measures, is an indicator of compliance). Another working paper which emphasises the importance of legislative, among other measures, to ensure national implementation and demonstrate political support for the convention is 'National implementation of the Biological Weapons' Convention, submitted by Australia, Japan, Malaysia, Republic of Korea and Thailand, BWC/MSP/2014/MX/WP.11, 5 August 2014.

22 'We need to talk about compliance: a response to BWC/MSP/2012/WP.11', BWC/MSP/2013/MX/WP.1, 2 July 2013, submitted by the United Kingdom of Great Britain and Northern Ireland, p.3 and 'Compliance with the BWC: preliminary considerations by Switzerland,' submitted by Switzerland, BWC/MSP/2013/MX/WP.12, 9 August 2013, p. 2.

23 'We need to talk about compliance: a response to BWC/MSP/2012/WP.11', BWC/MSP/2013/MX/WP.1, 2 July 2013, submitted by the United Kingdom of Great Britain and Northern Ireland, p.3

24 The US does not assess compliance with national implementing measure obligations in its formal compliance assessments of other BWC states parties; see *2015 Report on Adherence to and Compliance With Arms Control, Nonproliferation, and Disarmament Agreements and Commitments*, US Department of State, 5 June 2015, www.state.gov/t/avc/rls/rpt/2015/243224.htm

25 For example, see ''Intervention by India on strengthening national implementation (to the BWC Meeting of Experts, 2015), 13 August 2015.

26 Statement on behalf of the Non-Aligned Movement and other states parties to the BWC, by Delegation of the Islamic Republic of Iran, on national implementation, 13 August 2015 (to the BWC Meeting of Experts, 2015).

27 Switzerland and the Czech Republic have joined Canada in preparing sample submissions for such a process; see 'National Implementation of the BTWC Compliance Assessment', submitted by Canada and Switzerland, BWC/MSP/2012/MX/WP.17, 3 August 2012; and 'National implementation of the BTWC: compliance assessment: update', submitted by Canada, the Czech Republic and Switzerland, BWC/MSP/2012/WP.6, 5 December 2012.

28 BWC/MSP/2012/MX/WP.17, p. 2.

29 'Providing Reassurance on Biological Weapons Convention (BWC) Implementation', submitted by Australia, Brunei Darussalam, Chile, Costa Rica, Ecuador, Ghana, Japan, Malaysia, Norway, Republic of Korea and Thailand, 11 August 2015.

30 'Next steps on the CBMs: some key questions for 2013', submitted by the United Kingdom of Great Britain and Northern Ireland, BWC/MSP/2012/WP.1, 12 November 2012.

31 'BENELUX BTWC Peer Review, outline of key features and objectives', submitted by Belgium, Luxembourg and Netherlands, BWC/MSP/2015/MX/WP.13/Rev.1, 10 August 2015.

32 '3D Bio: Declare, Document and Demonstrate', *Non-Proliferation Papers* No. 45, EU Non-Proliferation Consortium, April 2015, www.nonproliferation.eu/web/documents/nonproliferationpapers/3b-bio-declare-document-and-demonstrate-46.pdf.

V&I

CHAPTER 9

The Arms Trade Treaty: making a difference

Jo Adamson and Guy Pollard

> *This is a victory for the world's people. The ATT will make it more difficult for deadly weapons to be diverted into the illicit market and it will help to keep warlords, pirates, terrorists, criminals and their like from acquiring deadly arms. It will be a powerful new tool in our efforts to prevent grave human rights abuses or violations of international humanitarian law. And it will provide much-needed momentum for other global disarmament and non-proliferation efforts. I applaud States for their willingness to compromise on a number of complex issues, thus making it possible for us to have a balanced and robust treaty text.*
>
> —Ban Ki-moon, 2 April 2013

On 2 April 2013, the United Nations General Assembly adopted the Arms Trade Treaty, with 154 votes in favour, three votes against—DPRK, Iran and Syria—and 23 abstentions. Twenty months later, on 24 December 2014, the treaty entered into force.[1] This is one of the shortest time periods to date for a treaty to take legal effect.

Upon the UK's ratification on 2 April 2014 the then British Foreign Secretary William Hague stated that 'This Treaty will help make the world safer, by placing human rights and international humanitarian law at the heart of decisions about the arms trade. For the first time, countries have agreed international rules governing everything from small arms to warships. If these rules are implemented globally and effectively, they have the power to stop arms from reaching terrorists and criminals, and fuelling conflict and instability around the world'.

Those words speak to the ground-breaking nature of the Arms Trade Treaty, but also to the challenges ahead to ensure that the treaty delivers its full potential: reducing conflict, saving lives and reducing human suffering.

This chapter examines what the Arms Trade Treaty is, the negotiations which led to its conclusion, and how the international community might work together to make a difference in the treaty's first years of operation.

In a difficult international context including ongoing conflicts in Iraq, Libya, Syria, Ukraine, the chapter argues against re-fighting old diplomatic battles over the meaning of text, instead focusing on achieving quick wins to demonstrate the relevance of the treaty and to cement the foundations of the new 'Arms Trade Treaty community'.

What is the Arms Trade Treaty?

The Arms Trade Treaty or 'ATT' is like no other treaty on arms regulation. It was not born through an already-established practice and contains elements never before seen in treaty law, for example, 'principles'. It is full of constructive ambiguity which can either help or hinder its implementation, and has elements which need further development, such as on reporting and definitions. As a legally binding document, the text of the treaty must be read in its entirety and as a self-reinforcing whole. The Geneva Academy has produced a useful commentary on each section and articles of the ATT to help readers become more familiar with the text.[2] For the sake of brevity, it is worth highlighting here some key elements that form the building blocks of the agreement.[3]

The ATT is the first global, legally binding instrument to regulate the international trade in conventional arms. It establishes global rules to be enforced by national authorities. One of the key differences between the ATT and previous approaches to conventional arms is that it moves beyond the focus solely on *illicit* trade and requires states to assess the potential negative consequences of arms exported in *legitimate* transfers. The ATT is also more explicit about the potential link between arms transfers and the commission of gender-based violence, including sexual violence in conflict. Transparency is also at its heart, again moving away from voluntary political arrangements, such as the UN Register on Conventional Arms Transfers (UNROCA), toward obliging states parties to keep records, report on implementation measures and to report annually on any transfers and export control decisions made.

The ATT comprises 28 legally binding articles, which are framed by the preamble and principles. Most important of these articles is the object and purpose of the treaty laid out in Article 1. Unlike many other treaties the object and purpose of the ATT is divided into two parts.

The first part describes the 'object' of the treaty, to:

- Establish the highest possible common international standards for regulating or improving the regulation of the international trade in conventional arms; and
- Prevent and eradicate the illicit trade in conventional arms and prevent their diversion.

The second part sets out its 'purpose':

- Contributing to international and regional peace, security and stability;
- Reducing human suffering;
- Promoting cooperation, transparency and responsible action by states parties in the international trade in conventional arms, thereby building confidence among states parties.

Thus, the reason and motive behind the ATT is the establishment of the highest possible common international standards for regulating the conventional arms trade and preventing illicit trade. This in turn will result in: contributing to international and regional peace, security and stability; reducing human suffering; and promoting cooperation, transparency, and responsible action by states parties—thereby building confidence between them.

To fulfil Article 1, the authors of the ATT recognised that international trade in conventional arms remains a national responsibility and therefore the only way an ATT could work would be to oblige states parties to take certain national steps in order to achieve the overall international objective. Importantly, the ATT tells states what they must do, but not how to do it.

Under the ATT, states parties are obliged to:

- Establish and operate a national control system that applies to the broadest range of conventional arms.
- Prohibit exports that will be used for genocide, crimes against humanity, or a broad range of war crimes.
- Undertake a mandatory risk assessment for arms exports—including ammunition/munitions, and parts and components—to be assessed on the basis of criteria including peace and security, human rights, international humanitarian law, terrorism and transnational organised crime.
- Refuse to authorise transfers if they pose an overriding risk of possible negative consequences.
- Take into account, in export licensing decisions, the risks of serious acts of gender based violence and violence against women and children.
- Regulate arms brokering.
- Maintain records and undertake regular reporting to the ATT secretariat, and through them to other states parties and the wider public (where agreed) on authorisations or exports of conventional weapons made.

In addition, states are encouraged to:

- Regulate imports, transit and transhipment of conventional arms where it is practicable and feasible.
- Cooperate with each other to prevent the diversion of weapons to illicit trafficking or use.

The ATT is not a panacea that will solve all the problems surrounding unregulated and illicit trade in conventional arms, but if properly implemented it has the capacity to lead to a better regulated international trade, to choke supply to the illicit market and evolve over time to keep pace with new developments. In this respect it is important to note that the treaty contains a provision to make sure it is future-proofed and to ensure that the instrument keeps up to date with possible new types of weaponry.

Why an Arms Trade Treaty? The long road to effective rules

The Arms Trade Treaty is not a new idea. Shortly after the end of the First World War several states[4] negotiated the 'Convention for the Control of the Trade in Arms and Ammunition'.[5] This was signed at Saint-Germain-en-Layne on 10 September 1919. Its main provisions set out a prohibition on:

> the export of the following arms of war: artillery of all kinds, apparatus for the discharge of all kinds of projectiles or gas-diffusing, flame throwers, bombs, grenades, machine-guns and rifled small bore breech-loading weapons of all kinds, as well as the exploitation of the ammunition for use with such arms. The prohibition of exportation shall apply to all such arms and ammunitions, whether complete or in parts.

This prohibition on exports was to be confined to the whole of the continent of Africa (except Algeria, Libya and South Africa), Transcaucasia, Persia, Gwadar, the Arabian Peninsula, and parts of the Turkish Empire.

Despite its lofty ambitions prohibiting transfers of a wide array of weaponry, ammunition, parts and components, it never entered into force. Had it done so, the security landscape may look very different than it does today and there would have been no need for the Arms Trade Treaty of 2013. Instead, lacking such an instrument and fuelled by irresponsible trade, the proliferation of conventional weapons flourished. Today it is the main contributor to conflict and armed violence, gives non-state actors the means to commit terrorist atrocities and destroys livelihoods causing human suffering.

Following the conclusion of the Second World War, attention turned to the destructive power of the weapons of the atomic age, and for much of the second half of the twentieth century, international arms control focused on trying to eliminate these 'Weapons of Mass Destruction'.

In the 1970s, an increase in the trade of arms was stimulated in the wake of the Yom Kippur War as the US armed Israel and Russia armed Syria and Egypt. Other Middle East countries amassing considerable wealth following the Organization of the Petroleum Exporting Countries (OPEC) oil embargo in 1973 also began to purchase large amounts of conventional weaponry for self-defence. Following this, the UN General Assembly (UNGA) adopted by consensus the Final Document of the First

Special Session on Disarmament (SSOD1) in 1978.[6] This document called on all states to negotiate limiting the scale of the arms trade. However, this initiative faltered and no concrete progress was made. The only firm result was the creation of the UN Instrument on Reporting of Military Expenditures in 1980, which attempted to bring some transparency to an otherwise opaque world of arms transfers.[7] However, its success is questionable as it still lacks universal participation on a regular basis.

Given large imbalances of conventional forces between NATO and the Warsaw Pact nations, arms reductions appeared unlikely and international negotiations emphasised establishing national limits on holdings of large systems such as battle tanks, combat aircraft, warships and missiles. The result was the adoption of the Treaty on Conventional Armed Forces in Europe in 1990.[8] The invasion of Kuwait by Iraq in the same year gave a renewed urgency to combating the proliferation of conventional arms, and in particular more sophisticated weaponry. In the immediate aftermath of the multinational conflict that followed, the Five Permanent Members of the UN Security Council (P5) agreed to restrain their supply of weapons to third parties.[9] Through a statement issued in Paris in 1991, the P5 'noted with concern the dangers associated with the excessive build up of military capabilities, and confirmed they would not transfer conventional weapons that would undermine stability'.

By October 1991, the P5 had agreed to a set of 'Guidelines for Conventional Arms Transfers'.[10] These guidelines included some of the risk assessment provisions now featured in the current ATT, such as avoiding transfers that support or encourage terrorism or those prolonging or aggravating existing conflict. However, this collaborative momentum was short lived. By 1992, internal arguments among the P5 over exports of weapons to Taiwan and non-state actors led to a break down in cooperation.

Following the end of the Cold War, observers noted an explosion in the number and frequency of 'low intensity' conflicts, especially in Africa. It is instructive to look at the high proportion of UN Peacekeeping Operations established since 1988–56 out of a total of 69 since 1948—and how the UN was increasingly called on to intervene in intra-state as well as inter-state conflicts.[11] Those conflicts were often characterised by a reliance on small arms and light weapons, and other conventional weapons, which flooded into conflict zones through a mixture of legitimate and illicit routes. Similarly, in Latin America and the Caribbean, low economic growth stimulated domestic crime and armed violence. Gun crime took hold with vicious and bloody clashes between rival drug gangs and the police become commonplace; the easy availability of firearms exacerbated the problem.[12]

Former UN Secretary General Kofi Annan has described conventional weapons as 'weapons of daily destruction'. The statistics make for alarming reading. A 2001 study by the Small Arms Survey estimated that 500,000 civilians died annually as a result of the misuse of conventional weapons—or one civilian every minute.[13] A 2007 Oxfam Briefing Paper estimated that conflict was costing Africa's economy some US$18 billion a year, with $300 billion lost between 1990 and 2007.[14]

Yet the international community was at first slow to adapt to the challenge. Writing in the 2002 edition of the *VERTIC Verification Yearbook*, Kate Joseph and Taina Susiluoto recalled a time when controlling the transfer and use of small arms and light weapons was thought to be 'not only impossible but also undesirable'.[15] Small arms and light weapons had many legitimate uses, for example in law enforcement, and were so widely available that it was considered naïve to seek to 'put the genie back into the bottle'.

The initial international response consisted of a series of self-standing regulations, projects and standards, which were mainly focused on transparency and against illicit trade and trafficking. They included the UN Register of Conventional Arms (1991);[16] UN Guidelines for International Arms Transfers (1996);[17] the UN Programme of Action to Prevent, Eradicate and Combat the Illicit Trade in Small Arms and Light Weapons (2001);[18] the UN Protocol against the Illicit Manufacturing of and Trafficking in Firearms, their Parts and Components and Ammunition or Firearms (2001);[19] and the International Tracing Instrument (2005).[20] Regions and like-minded groupings also took matters into

Box 1 Regional approaches to addressing arms trade

Africa: Bamako Declaration on the Illicit Proliferation, Circulation and Trafficking of Small Arms and Light Weapons 2000;[21] Nairobi Declaration 2000;[22] Southern African Development Community Council Decisions on the Prevention and Combating of Illicit Trafficking in Small Arms and Related Crimes 1999;[23] Organisation of the African Union Decision on the Proliferation, Circulation and Illicit Trafficking of Small Arms and Light Weapons, 1999;[24] the Economic Community of West African States Convention on Small Arms and Light Weapons, their Ammunition and Other Related Materials, 2006;[25] Protocol on the Control of Firearms, Ammunition and Other Related Materials in the Southern African Development Community Region.[26]

Americas: Inter-American Convention Against the Illicit Manufacturing of and Trafficking in Firearms, Ammunition, Explosives and Other Related Material, Organisation of American States, 1997;[27] Inter-American Convention on Transparency in Conventional Weapons Acquisitions Organisation of American States, 1999;[28] Brasilia Declaration of the Latin American and Caribbean States, 2000.[29]

Asia-Pacific: Association of Southeast Asian Nations Regional Forum, 1993;[30] Colombo Declaration 2000;[31] Honiara Initiative, 1998;[32] and the Nadi Framework Model Weapons Control Bill (Pacific Island Forum), 2003.[33]

Europe: European Union Code of Conduct for Arms Transfers, 1988;[34] Organisation for Security and Co-operation in Europe Forum for Security Cooperation and Confidence and Security Building Measures, 1992;[35] Wassenaar Arrangement, 1996;[36] and European Union Programme for Preventing and Combating Illicit Trafficking in Conventional Arms, 1997.[37]

their own hands in an effort to address the issue and established a patchwork of declarations, protocols and conventions (see Box 1).

Each of these initiatives made a positive contribution to tackling the proliferation of conventional weapons. But in the first decade of the twenty-first century, calls were growing for a more comprehensive and legally binding approach to tackle the problems of patchwork regulation, legal loopholes, lack of transparency, and a growing globalisation of the arms trade.

A game changing moment occurred in 2000 when a group of NGOs proposed a 'Draft Framework Convention on International Arms Transfers', which called for a universal, legally binding agreement governing arms transfers.[38] This built on ideas first proposed in 1997 by a group of Nobel Laureates led by former Costa Rican President Oscar Arias.

In the first few years, the initiative found only a handful of state supporters. It was not until the Control Arms Campaign for an Arms Trade Treaty was launched in 2003, with support from Costa Rica, Cambodia and Mali that this idea started to gain traction. With the UN Programme of Action in its infancy many states were sceptical of the value a new treaty would bring over the recently agreed arrangement that was not thoroughly implemented. What the Control Arms Campaign needed was a major arms manufacturer and exporter to support them. It was the United Kingdom.

Despite its initial scepticism over the proposed ATT, the United Kingdom became champion and leader of the process, providing the necessary boost to start its journey from concept to reality. In late 2004, the scene was set for discussions to begin towards building a robust and effective ATT.

How the Arms Trade Treaty was negotiated

The road from the 'Draft Framework Convention' to the adoption of the Arms Trade Treaty on 2 April 2013 was remarkable not just for the route taken, but also for those who made the journey together, and for the different drivers at the wheel in different stages.

Phase one—supporters and plan

Now firmly backing an ATT, the UK Government set about creating a group of core supporters to construct a plan for the negotiations and start the momentum necessary for achieving a treaty.

The context and setting for the negotiations were important. For an Arms Trade Treaty to be most effective, it would need to contain the highest possible standards and enjoy the participation of the broadest possible group of countries. In addition, it would need buy-in from countries with the greatest influence over the arms trade, including major arms exporters and importers.

In early 2005, various options to progress the ATT were discussed and discarded. The United Nations was the traditional setting for discussions on arms control and disarmament, but there were challenges. The UN Conference on Disarmament in Geneva had been in stalemate since 1998; the Convention on Certain Conventional Weapons was still negotiating Explosive Remnants of War and looking to negotiate a Protocol on Anti-Vehicle Mines; and the World Trade Organisation did not regulate arms.

Taking negotiations outside of the traditional architecture had provided results. Instruments on conventional arms, including the 1997 Anti Personnel Landmines Convention and the 2008 Cluster Munitions Convention had been negotiated outside the UN, initiated by a group of like-minded states. While negotiating these types of treaties had their attractions, as they were not bound by UN process, budget or rules of procedure (including the need to strive for consensus), they were not seen as inclusive enough for what the ATT was set to achieve as a number of relevant countries—China, India, Pakistan, Russia, the US—had remained outside those new instruments and had stood aside from the negotiations. Therefore, it was decided that, despite the hurdles, only a new process using all the negotiating tools available under the United Nations, could provide the necessary platform.

To initiate the process a resolution had to be put before the UNGA First Committee. However, the UK was wary of doing this on its own. It therefore sought a core group of like-minded countries to help 'co-author' the resolution and kick-start the process. The UK felt it would be beneficial to form a group that represented the entirety of the regions around the globe. Initially, 12 countries were approached to join the UK as co-authors. Ultimately, seven states were willing to support the UK and the ATT.[39] As co-authors, they put forward the first resolution in 2006 entitled 'Towards an arms trade treaty: establishing common international standards for the export, import and transfer of conventional arms'.[40]

The resolution in 2006 contained two important elements. First it sought UN member states views 'on the feasibility, scope and draft parameters for a comprehensive, legally binding instrument establishing common international standards for the import, export and transfer of conventional arms' and second, it created a Group of Governmental Experts (GGE) to examine the issue.

The GGE would not sit until 2008, due to UN budgetary programming requirements, but prior to that, states were busy submitting their views. For the first time in the UN's history more than 100 states answered the call to submit their views to the UN Secretary General on a specific issue. Civil society was instrumental in this and campaigned hard to ensure that the UN heard from all of the ATT supporters that such a treaty was feasible and desperately needed.

In 2008, the GGE sat for a period of four weeks. GGEs in the UN system are usually composed of 15 experts, but given the enormity of interest in this process, the GGE was expanded to 28 members.[41] This activity marked the start of the process and it could have easily failed at that point if the group could not arrive at a consensus decision on the way forward. For it to succeed a good chairperson was required, preferably also one of the co-authors of the resolution. Having previously chaired the GGE on the UN Register on Conventional Arms, Argentinean diplomat Ambassador Roberto Garcia Moritan accepted this task and steered it to its conclusion. The consensus recommendation that 'further consideration of efforts within the United Nations to address the international trade in arms is required on a step-by-step basis, in an open and transparent manner . . . on the basis of consensus . . .' was enough to facilitate moving to phase two.

Phase two—inclusivity

The resolution's co-authors were quick to seize on the results of the GGE and put forward another resolution in 2008, which established the next step in the process.[42] This was the creation of an open-ended working group (OEWG) to 'further consider those elements in the report of the Group of Governmental Experts where consensus could be developed for their inclusion in an eventual legally binding treaty . . .'. This process allowed all UN member states to take part in the discussions over six one-week sessions from 2009.

The first two sessions in 2009 showed that progress was not being made; many of the same arguments put forward in states' responses to the UN Secretary General were being reiterated to a wider audience. However, all states had a chance to participate in this process and all views were heard. Again, Ambassador Roberto Garcia Moritan was crucial in the success of this group and the report adopted by consensus concluded in paragraph 23 that:

> The Open-ended Working Group also recognized the need to address the problems relating to unregulated trade in conventional weapons and their diversion to the illicit market. Considering that such risks can fuel instability, international terrorism, and transnational organized crime, the Group supports that international action should be taken to address the problem.[43]

With this recognition agreed by consensus by all UN member states the time was now opportune for the co-authors to push forward with phase three.

Phase three—preparation for negotiation

The most important resolution for the ATT was in 2009.[44] Building on the outcome of paragraph 23 of the OEWG report, the co-authors believed that they had legitimacy to establish a Diplomatic Conference in 2012, and change the remaining sessions of the OEWG into Preparatory Committees. The only remaining difficulty was the issue of consensus.

Up until that point, the United States had opposed the various ATT resolutions and been sceptical of the process and thus it was important to bring them on board. A change in the political landscape in the US enabled the country to support the ATT, but only if the co-authors could accept the Diplomatic Conference being governed by the rule of consensus on the adoption of any outcome. This was, however, highly controversial. Processes under the General Assembly rules were governed by majority vote. This would change that and create a new precedent that could be used for other issues. Such a change was not an easy sell to the rest of the supporters or civil society who associated consensus with stagnation, lack of progress, and lowest common denominator. Even the co-authors opinions were divided on this issue.

Nevertheless, buoyed on by the prospect of US support, the co-authors agreed to put forward the consensus rule for the final outcome for the conference and vote it through. By 153 in favour to 1 against (Zimbabwe), and 19 abstaining, the Diplomatic Conference was established, the Preparatory Committees set, and the end of the ATT process was in sight.

During 2010 and 2011, the Preparatory Committees took place. These four weeks of preparation had been intended to pull together the beginnings of a draft treaty, which could have been used as the basis for negotiations in the Diplomatic Conference. However, states were not prepared to negotiate at this early stage, preferring instead to reiterate their views on what an ATT could and should do. Differences of opinion were vast, and progress on areas of consensus was slow. At the end of this process, an ATT was no further forward and, despite having various options to put on the table, the chair decided to begin the 2012 Conference with no informal paper on which to launch negotiations.

Phase four—the negotiation, part i

The first ATT negotiating conference in July 2012 did not get off to an auspicious start. Two days of the first week were lost at the opening as the chairman and delegates sought a solution to seating arrangements for Palestine and the Holy See. This was an unnecessary problem created by a dispute as to whether the conference was a 'UN Member State' Conference or an 'All States' Conference. A (unconventional) solution was found whereby Palestine and the Holy See sat at the front of the room before states were seated in alphabetical order. With this, and after a break for 4 July celebrations, the conference began its substantive work.

Having lost three working days already, the chair appointed several facilitators to assist in the negotiations. Main Committees, formal and informal, were established, which allowed civil society to some and not to others. Civil society were also on some delegations which negated the need to close some meetings to them. In addition, by the end of the second week, the chair began holding late night informal meetings. Following the meetings from 10am to 1pm and then 3pm to 6pm, the chair began to hold meetings in the Indonesian Lounge in the UN Main Building in New York from 8pm till early morning. This lounge was not set up for meetings and an improvised cinema-like arrangement had to be put in place to allow the drafting of certain texts. However, this method of late nights, hot cramped rooms coupled with food and sleep deprivation was not favoured by many delegates and several began to lose faith in the chair.

The main substantive arguments during these negotiations focused on the following:

- *Scope of the treaty:* many advocated a broad approach so that the treaty covered *all* conventional arms but there were difficulties with definitions. No definitions of conventional arms existed in the international sphere except for UNROCA, which many, especially civil society, believed to be inadequate. However, it was certainly not possible to begin defining conventional arms at this late stage as that could have taken many months to conclude in itself. Others wanted non-lethal items, body armour or a difference between military and non-military weaponry to be included.
- *Small Arms and Light Weapons (SALW):* these types of weapons were not covered by the seven categories of the UNROCA and it was essential for many that SALW were included. For such people, this was the raison d'être for the ATT. However, there were issues over domestic and personal use, how to treat weapons used for hunting and sports, and also constitutional rights. This campaign was very vocal particularly through the US National Rifle Association (NRA). They remained sceptical of the ATT believing that it affected the 2nd Amendment of the US constitution. Despite the ATT being about international transfers, they saw this as an opportunity to scaremonger in the US and gain political and financial support especially as gun related incidents and public backlash was on the increase domestically.
- *Ammunition:* without ammunition many saw the ATT as an empty vessel, but the US did not want it included. They believed that it was impossible to place import controls on ammunition or prevent its diversion to the illicit market as the quantities in question were too large to properly address. They also believed that record

keeping of ammunition would be very costly and time consuming for no practical benefit.

- *Transactions covered:* the ATT resolutions and process had highlighted three main elements to be covered in any future treaty: import, export and transit/transhipment. But the question about whether gifts, leases, or loans were covered remained unanswered.
- *Diversion to the illicit market:* this was key for many Latin American states, particularly Mexico. However, given the issues with ammunition, the volumes dealt with and the reluctance of some states to include it within the scope of the ATT, it was unclear how diversion would be tackled by the treaty. Two solutions were put forward: either include diversion as a core criteria for the risk assessment and not include ammunition in the scope of the instrument, or include ammunition in scope but do not apply the diversion criteria to it. This would only really be solved in the Final Conference.
- *Risk Assessment Criteria:* these provisions would list what factors should be considered by national authorities when assessing transfers, including human rights and international humanitarian law. There were many examples in existence for risk assessment (such as the EU Code of Conduct, ECOWAS guidelines, and national criteria), but the delegates could not agree on which factors should be included in an ATT criteria list. Despite intense efforts, agreement was not reached.
- *Defence Cooperation Agreements (DCAs):* several states, in particular India, did not want existing DCAs to be voided by an ATT and sought to create an exemption but this created a large loophole which many feared could completely undermine the prospects of a strong and robust ATT.
- *Entry Into Force:* some states wanted similar arrangements to those found in the Comprehensive Test Ban Treaty, with the largest exporters having to ratify before it could enter into force, others wanted just 20 states to trigger the entry.
- *Amendments:* a debate occurred on how to review the text of the treaty to ensure it remained relevant and implementable, for example, through reviewing whether the scope of the treaty remained adequate and whether certain articles were having the desired impact. This discussion was contentious with some arguing for a long implementation period before any review and others wanting regular Review Conferences.
- *Regional Organisations:* there was a question over whether the treaty could be open to regional organisations, such as the ECOWAS and the European Union, to join as states parties similar to some Climate Change Conventions. However, this was a sticking point for China, which is still subject to an EU arms embargo.

After a month of heated debate, Ambassador Moritan tried to pull the different strands together and attempted to chart a middle path with a paper he produced on 26 July.[45] However, the United States, supported by Russia, China, Cuba and others called for more time on the final day to consider this text. This caused outrage from many who had worked hard to secure the ATT during this conference and several declared that they could have adopted such an instrument. However, with consensus nowhere in sight, Ambassador Moritan's time was up and the conference ended without a result. On reflection this was no bad thing. The text of 26 July was far from perfect and did not fit together correctly. Had it been adopted at that time, it would have been a missed opportunity.

The negotiation, part ii

At the UNGA First Committee of 2012, the co-authors submitted a new resolution, which established the Final Diplomatic Conference.[46] Many objected to the word 'Final' in the title feeling that the process could continue, but the co-authors and supporters were adamant that the ATT would be finalised at this conference. To ensure this happened, operational paragraph 7 was added to the text. This paragraph kept the agenda item for the ATT open during the 67th Session of the General Assembly and requested the chair to report to the GA as soon as possible after the end of the meeting. This paragraph allowed for the ATT to move to the GA and be adopted by vote, should consensus not be achievable by the end of the conference.

After a break of eight months and with a new Australian chair, Ambassador Peter Woolcott, the Final Conference was held from 12–29 March 2013. In preparation for this, Ambassador Woolcott travelled extensively. He was also helped through the resolution, which had cited that the 26 July 2012 text, to provide the basis for his consultations. This crucially meant that there was a solid foundation for negotiation in the Final Conference.

At the outset of the Final Conference, there were no procedural seating issues and delegations came prepared to negotiate. Many of the same arguments took place, but the delay had allowed states to 'tidy up' the text into clearer legal language and the chair quickly put forward a revised version. Working in the plenary sessions and consulting with various groups on the tricky issues, a text began to emerge and develop as the conference continued. On the penultimate day, the chair put forward a 'take it or leave it' text. It was a text that he believed could command consensus and was as robust as it could have been. The tricky issues identified above had been solved as follows:

- *Scope of the treaty:* the chapeau referred to 'all conventional arms within the following categories' and the categories were defined by relevant international instruments—

UNROCA and the Firearms Protocol. The view taken was that all conventional arms fell within these eight categories, most importantly including SALW. However, some have suggested that now only landmines and hand grenades fall outside the scope of the ATT and must be addressed when the time comes for amendment.

- *Ammunition:* using both English terms 'ammunition/munitions' meant that all forms of ammunition and artillery used in conventional arms were covered. To get around the earlier US problem, only Article 6 and 7 were applicable to ammunition and parts and components, meaning that diversion and record keeping were not applicable for these transfers.
- *Transactions covered:* the only definition in the ATT was 'the activities of the international trade comprise import, export, transit, trans-shipment and brokering'. The question as to whether this covers gifts, leases, or loans remains a live debate, but it was this ambiguity that allowed certain states to accept the ATT and ultimately to join it.
- *Diversion to the illicit market:* a significant development over the 2012 text was the inclusion of a separate article on diversion compelling states to co-operate to prevent diversion of weapons. This also was reflective of the objective of the ATT and despite controversy over non-state actors, end use and end users; it was a welcome addition and an area for future implementation.
- *Risk Assessment Criteria:* this became a balancing act where the negative consequences of a transfer are weighed against the positive consequences. Violation of International Humanitarian Law, International Human Rights Law, offences under terrorism instruments, and offences of transnational crime, became the four key criteria on which to assess an arms transfer. Additionally, the risk of the arms being used for gender-based violence or diverted, while not at the heart of the risk assessment or part of the 'balance' to be made between positive and negative consequences of the transfer, are factors that need to be taken into account by the authorising state. The weight, accorded to these factors, remains a national decision.
- *Defence Cooperation Agreements:* given earlier legitimate concerns over the possible creation of a loophole in the ATT, this article was confined to those Defence Cooperation Agreements made only between ATT states parties and not third parties as originally drafted.
- *Entry Into Force:* given variances in views on this issue and the plethora of examples available, the chair unilaterally decided on the number 50.
- *Amendments:* based on the Tobacco Framework Convention, this procedure allowed for the initial implementation of the ATT before allowing the treaty text to be open for amendments. Even then, despite the rules governing decision-making for the

Conference of States Parties, the threshold for these amendment decisions was three quarters of states parties present and voting.

- *Regional organisations:* this issue remained a sticking point and in the end their participation as states parties was not accepted.

On the final day, the chairman's text was put forward for adoption, but was blocked by DPRK, Iran and Syria who cited references to the UN Security Council arms embargoes in Article 6 as unacceptable and therefore could not allow the adoption of the text.

A group of like minded countries, including the co-authors, the United States, Nigeria, and Mexico took the floor to table their proposal to submit a resolution to the General Assembly on Tuesday 2 April, to adopt the ATT as contained in the chair's paper. On the Tuesday, following a brief commentary of the final negotiations by Ambassador Woolcott, the General Assembly voted in favour and adopted the Arms Trade Treaty.

The three states that had opposed the adoption by consensus of the treaty text in the Diplomatic Conference were outvoted in the General Assembly and the treaty was opened for signature on 3 June 2013.

Why did the ATT process work?

At the outset, the process was well thought out and calculated. Using the modalities of the UN in a systematic way from GGE to OEWG to Preparatory Committees to Diplomatic Conference, and using consensus in a manner that could be broken in the end, was the only way success could be achieved.

The campaign stage of the ATT, early engagement with industry and the crucial vocal support of civil society were instrumental in awareness raising in states and among the public which put pressure on individual governments through targeted campaigns. Outreach by the co-authors and in particular the UK was very efficient at winning over support. The reason for this was that a different, or tailored, message was conveyed to each different group; a message that was relevant to the group's interests and concerns. The global vision of the ATT differed depending on who the target audience was. For Africa, they hoped that the ATT would be the legally binding 'Small Arms Treaty', for Latin America it was about tackling diversion, armed violence and criminal gangs, and for Europe and the US, it was the creation of a responsible global trade and a levelling of the playing field in that trade ensuring that all major exporters were applying the same criteria in their arms exports.

The negotiating process itself was marked by the emergence of a number of coalitions and like-minded groups. The co-authors were made up of exporters and importers from different continents, with the aim of working regionally as well internationally at the United Nations. Control Arms brought together a wide range of different civil society groups, including NGOs, parliamentarians, medical professionals, survivors of conflicts, and regional groupings. Industry added their own thoughts on practical implementation particularly on how to manage 'parts and components'. Some countries caucused on the basis of regional arrangements. Others clustered to advance specific issues such as gender-based violence and sustainable development. Leadership was shared among individuals and coalitions. Crucially, the UN political groupings were split and redundant. States were freer to engage with like-minded states and drive common agendas. The two chairs pushed UN member states towards consensus but expected delegates to engage in genuine negotiations and drafting. The final text contains echoes of speeches and written contributions from numerous delegations.

How can the Arms Trade Treaty make a difference?

The ATT entered into force on 24 December 2014. At the time of writing, it has 130 signatory states and 72 states parties.

With many potential areas of activity, it will be important for the international community to prioritise, and not politicise, future work for the ATT. Based on the experience of negotiating the text, the following could serve as organising principles:

- Reaffirming the fundamental aims of the ATT should remain a guiding principle underpinning every action. These include saving lives, reducing conflict and human suffering, promoting human rights and IHL, supporting development and fighting terrorism.
- Examining and exploiting the ATT's relationship with other instruments. In this regard the Chatham Houses research paper on the 'ATT's Interaction with Other Related Agreements' has some interesting ideas that states parties should consider in order to develop the ATT's potential to improve global control capacities and maximise potential synergies with other instruments and forums.[47]
- Communication activities could be geared to showing the ATT in action, for example in countries undertaking export or import controls for the first time, or supplemental activities. Now more than ever the treaty needs a diverse group of champions to demonstrate that it belongs to all of those affected by the arms trade.
- The first year should focus on the practical business of setting up the secretariat and bringing states together for the first Conference of States Parties. By the time of publication, the first conference is due to have taken place where it is hoped a decision will be made on Rules of Procedure, the Secretariat (location and head),

and financial rules. Hopefully, the conference will also have achieved some quick wins, for example agreement on ‘Reporting’ and agreement to have a mechanism to continue work on certain issues, for example, end use/r certificates. But in any case, two observations can be made on the negotiating process in general. First, it is hoped that the conference, and any subsequent meetings, maintain the coherence of the treaty and do not risk fracturing it. The text of the Arms Trade Treaty was negotiated over six years. It is what the market will bear. Success should be measured by results on the ground. Second, negotiations in the development phase of the treaty showed that good progress can be made if priorities are discussed among a broad group of participants, and some delegations are asked to lead on specific issues.

- States parties and other stakeholders should seek to consolidate and enlarge the new ATT community. The goal of universality should guide outreach and communications to sceptics. This should apply to civil society participation as well as to states—the ATT negotiating process was enriched by the presence of diverse voices. Industry representatives were critical to ensuring that the practical implications of decisions were taken into account at the point of negotiation, not as an afterthought.
- The ATT community should think about how to measure the impact and success of the treaty over the long term. NGOs play a useful role in monitoring implementation. Figuring out how the treaty has affected conditions on the ground is a complex issue, as it is notoriously difficult to distinguish between causation or simple correlation. A good first step might be to seek to establish baseline information against which the international community can measure change. In this regard, the Baseline Assessment Survey, which allows states to publish what measures they have put in place to control the arms trade, whether or not they are states parties of the ATT, is a useful start and one that should be encouraged.[48] In addition, Control Arms and the ATT Monitor, will be crucial in monitoring future implementation and a useful tool in the analysis of what impact the ATT will have.

Conclusion

Speaking on 28 March 2013, after three countries had blocked the adoption of the Arms Trade Treaty, the UK said, ‘this is not failure, this is success deferred’. This statement was born out with the adoption of the ATT on 2 April 2013. But that event merely marked the end of the beginning. There is still some way to go. The international community is embarking on the painstaking business of building the new architecture that will transform the ATT from text to tools. The positive energy that drove negotiators to be ambitious is still there. Technical and legal expertise is abundant. The availability of a UN Trust Fund should ensure that projects are funded that can make a real difference in the ATT's first year. The international context may be difficult but if properly managed the ATT could yet be a forum that brings countries together despite their other differences. That is certainly how the ATT was negotiated. It is how it should be implemented.

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the UK government or of its agencies.

Endnotes

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CHAPTER 10

Fundamentals of cyber security

Dave Clemente

Introduction

Cyber security is an increasingly relevant and pressing area of concern for individuals, companies and governments, and one that is hard to ignore. This chapter looks at primary factors that make cyber security both important and difficult to achieve. Analysis begins by looking at the evolving digital environment, continues with an examination of dynamics that make cyber security so challenging, and concludes with a look at possible futures.

The goal of this analysis is to cut through the hype that surrounds cyber security and to provide the reader with a clear yet nuanced perspective of what is important and why. This is a challenge when fundamental concepts are often poorly understood and where there are strong commercial and political incentives to exaggerate perceived dangers.

To understand what is meant by 'cyber security' it is helpful to begin by looking at a definition of cyberspace:[1]

> Cyberspace is an interactive domain made up of digital networks that is used to store, modify and communicate information. It includes the internet, but also the other information systems that support our companies, infrastructure and services.[2]

Cyberspace can be divided into a multi-layer model comprised of: [3]

1. *Physical foundations:* such as land and submarine cables, and satellites that provide communication pathways, along with routers that direct information to its destination.
2. *Logical building blocks:* including software such as smartphone apps, operating systems, or web browsers, which allow the physical foundations to function and communicate.
3. *Information:* that transits cyberspace, such as social media posts, texts, financial transfers or video downloads. Before and after transit, this information is often stored on (and modified by) computers and mobile devices, or public or private cloud storage services.

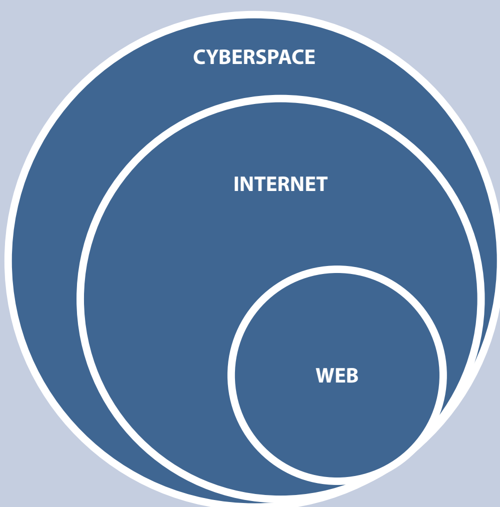
4. *People:* that manipulate information, communicate, and design the physical and logical components of cyberspace.

Collectively these tangible and intangible layers comprise cyberspace, which we are increasingly dependent on for essential components of daily life. A dependable and stable cyberspace is necessary for the smooth functioning of critical infrastructure sectors such as energy, transport, food, health and finance. As dependence increases, so do the costs of disruption—whether accidental or intentional—as well as possibilities for misuse and abuse.

The web is not the internet

When cyber security is mentioned, many people tend to think of the security of their devices, home or work computers, or the websites they visit on a daily basis. But cyberspace is much larger than this (see Figure 1 below) and includes the sum of global digital networks. It includes all digital communications including obscure and legacy communication protocols or isolated networks (for example, nuclear weapons silos) that are not accessible through the internet. The internet (the IP—or Internet Protocol—network) is a slightly smaller circle that includes the most popular and widely used forms of communication.[4]

Figure 1 Overlapping systems of digital communication



Inside the internet is yet another circle—the web, or the pages that can be accessed using a web browser such as Firefox, Chrome or Safari.[5] The internet and web are often used interchangeably, but in fact they are different and one of them sits inside the other. Although this chapter (and most popular commentary) talks about cyber security, what is really meant is security of the internet, where the vast majority of global communication takes place.

Author and journalist John Naughton provides a useful analogy to describe the difference between the internet and the web:

> Think of the internet as the tracks and signalling, the infrastructure on which everything runs. In a railway network, different kinds of traffic run on the infrastructure—high-speed express trains, slow stopping trains, commuter trains, freight trains and (sometimes) specialist maintenance and repair trains.
>
> On the internet, web pages are only one of the many kinds of traffic that run on its virtual tracks. Other types of traffic include music files being exchanged via peer-to-peer networking, or from the iTunes store; movie files travelling via BitTorrent; software updates; email; instant messages; phone conversations via Skype and other VoIP (internet telephony) services; streaming video and audio; and other stuff too arcane to mention.[6]

Cyberspace in context

The four layers of cyberspace described above (physical, logical, information, and people) have three primary characteristics—connectivity, speed and storage. These characteristics enable both the positive and negative aspects of the digital environment and should be understood in order to place cyberspace in context. This is also how readers can begin to understand cyber security—by examining the basic layers of cyberspace and their characteristics and analysing what this means for the safety and stability of the modern digital world.

Connectivity

Nearly 40 per cent of the world's population is connected to the internet, through PCs, laptops, tablets and mobile phones. In addition, there are billions of other connected 'things' such as sensors embedded in cars, factories, buildings, airplanes, TVs and toasters. This rapidly increasing connectivity produces value and benefits that are more than the sum of the individual parts. This is known as a positive 'network effect'—as more devices are connected, more information is generated and shared, and the value of the network increases for everyone.[7]

There are clear benefits, for example, from being able to email anyone around the globe who connected to the internet, as opposed to being restricted to Western Europe. The value of social networks, such as Facebook or LinkedIn, increases dramatically as more people join. Widespread connectivity also helps to identify trends and activities that were previously very difficult or impossible to spot, such as tracking the spread of infectious diseases.[8]

Connectivity allows text messages and documents to be sent reliably around the globe almost instantaneously, making distance irrelevant. This connectivity is good for employees working from home or students checking Facebook from a coffee shop, but it is equally good for hackers attempting to break into a computer on the other side of the world, or knock websites offline using the computing power of a botnet (that is, a group of computers that have been infected with malicious software).[9]

Speed

Why does cyberspace seem to change so quickly, presenting opportunities and challenges at greater speed than we are accustomed to in the physical world? There are a number of reasons for this change, and they are scattered throughout the twentieth century. They include the inventions of the semiconductor and transistor.[10] Steady advances in technology led Gordon Moore (co-founder of Intel) to state his belief that engineers would be able to double the number of transistors on a computer chip every two years.[11] This observation, known as Moore's Law, was made in 1975 and has held true for the past four decades. It means that the speed—processing power—of computer chips increases steadily, making laptops more powerful, turning smartphones into handheld computers, and allowing Google searches to be completed ever-faster. Squeezing more transistors onto a chip means greater speed, and speed underpins the digital world.

Storage

Greater connectivity and speed are nice, but they mean little without storage. What good is an email, text, spreadsheet or document if it can be sent and received, but not stored and retrieved? Storage capacity has come close to matching Moore's Law (namely, doubling roughly every two years) as hard drives have moved from gigabytes to terabytes and continue to grow.

Storage involves not only capacity, but also performance, which is the input/output speed of a storage device. Performance has increased dramatically with the transition, over the past decade, from traditional hard drives with spinning discs to solid state hard drives that have no moving parts—the same storage in smartphones and flash drives. Storage allows internet users to download and retain music, videos, pictures and much more. This is equally valuable for attackers who are looking for large repositories of information, or who wish to siphon large quantities of information from compromised networks.

Dependence and dual-use

The effects of this connectivity, speed and storage are many and varied, but at least two implications can be identified. First, the modern world is heavily dependent on digital technologies, often in ways that are subtle or not readily apparent. The internet facilitates the vast majority of digital communications, including financial transactions, telephone and video calls, and text messages. Critical infrastructure sectors such as food, transport, and water rely on digital connectivity to increase efficiency and profits. As James Lewis noted: 'the effect of the internet is to lower transaction costs—everything else is just advertising'.[12] This dependence on the internet as the central nervous system of the globe is growing steadily and shows no signs of slowing.

> We don't have cars anymore; we have computers we ride in. We don't have airplanes anymore; we have flying Solaris boxes attached to [many] industrial control systems. A 3D printer is not a device, it's a peripheral, and it only works connected to a computer. A radio is no longer a crystal: it's a general-purpose computer, running software.[13]

Second, all technologies are dual-use. There are no kinds of connectivity, speed or storage that will only benefit desirable actors and exclude undesirable ones. The benefits of this environment, for example, the ability to innovate without asking permission from anyone, are available to all actors, malicious or benign. This crucial point is often overlooked by policy-makers who attempt to impose technological solutions to societal problems as they ask 'can't you just make us a general-purpose computer that runs all the programs, except the ones that scare and anger us? Can't you just make us an internet that transmits any message over any protocol between any two points, unless it upsets us?'[14]

Cyber security in context

The three characteristics discussed above—connectivity, speed, storage—have been combined to create many opportunities but also threats. As the global economy becomes more dependent on the internet, and as attacks and data breaches become more costly, cyber security is receiving more attention from decision-makers in the public and private sectors.

Cyber security is about protecting the confidentiality, integrity and availability of information—whether it is personally identifiable information, email or other kinds of communication, credit card numbers, intellectual property or government secrets. Hackers, organised criminals, commercial competitors and government intelligence agencies are increasingly active on the internet and engaged in various kinds of theft, disruption, espionage and sabotage.

Defending computer networks and protecting information from these actors is a difficult and ever-changing task. Defenders must protect against all known vulnerabilities, while attackers only need to find one unprotected vulnerability (or discover a new one). The process of securing digital networks and information is a balance between competing priorities—investing in cyber security or, for example, expanding into new markets. It involves risk assessments of the kind that are familiar to decision-makers in the public and private sectors. However, these risk assessments are becoming more difficult as the digital 'attack surface' grows exponentially, and as connectivity spreads beyond PCs, laptops, and smartphones to include low cost, low margin devices.

These devices can now be placed into almost any device or location, allowing household appliances, cars, medical implants, and even farm animals to be connected to the internet.[15] The information that is generated or transmitted by these devices may be the target of attacks, but the software that runs them may also be the target.

All modern economies depend on software to operate transportation, communication, and energy networks along with many other aspects of daily life. Good software is difficult to create, and pervasive vulnerabilities make our computers crash inadvertently, allow hackers to evade detection and defraud our bank accounts, or government spies to secretly collect vast quantities of information. These vulnerabilities permeate computer networks and are a symptom of larger problems.

> Everything is broken [. . .] Software is so bad because it's so complex, and because it's trying to talk to other programs on the same computer, or over connections to other computers. Even your computer is kind of more than one computer, boxes within boxes, and each one of those computers is full of little programs trying to coordinate their actions and talk to each other. Computers have gotten incredibly complex, while people have remained the same grey mud with pretensions of godhood.[16]

These vulnerabilities pose a risk to personal information, intellectual property, government secrets and, potentially, to the infrastructure that underpins the internet. The cyber security community has consistently been outpaced by technological developments and, in a business environment, often struggles to articulate why spending on cyber security should take precedence over activities which more directly contribute to commercial profitability. Many proposals have been made to change this dynamic, from vendor liability for producing or selling insecure software to bonuses (instead of legal threats) for security researchers who uncover technical vulnerabilities, but little progress has been made. The pessimist would note that change is likely to come only after a large and damaging incident. The optimist would observe that, in spite of pervasive weaknesses, the digital environment functions well enough to serve as the nervous system of the global economy and financial markets.

Stability and shared interests

Significant investments have been made to ensure the reliable functioning of the internet, particularly by the companies that own the physical and logical infrastructure, and the result has been relatively few significant or sustained disruptions. In part this could be attributed to the benefits that all actors gain from an ever-expanding digital environment. For the benign actor the benefits include increased social and economic possibilities, as they can more easily shop online and communicate with friends and relatives around the world. For most malicious actors there is little incentive to disrupt the functioning of the internet. After all, the spread of connectivity means more naïve individuals who can be defrauded, and more computers that can be hijacked and used for profit.[17]

One major change over the past twenty years is the growth in global economic interdependency. This is a reliable stability mechanism and one that is reinforced by the growing use of the internet. Financial transactions, communication channels, media and entertainment networks—all of these transit the globe at the speed of light, with little regard or respect for the inflexibility of geographic boundaries.

Shared dependence on the smooth functioning of the internet means there is reduced incentive to destroy or disrupt it, as hackers and criminals would suffer along with everyone else. For governments, economic interdependence increases the costs (to everyone) of overt offensive action in cyberspace, and this has resulted in the steady growth of covert activities.

There are strong economic incentives to connect to the internet, and even stronger incentives to disconnect. Even when intentional disconnections take place, they cannot be sustained for long. The Egyptian government shut-off the majority of the country's internet during the Arab Spring (except for the connections that allowed the Egyptian stock market to continue functioning) but it could not sustain this action for more than five days.[18]

Financial connections entangle nearly every country in the world, and mutually assured nuclear destruction has been replaced by mutually assured economic destruction. For example, sanctioning Russia for its military actions in Ukraine by cutting it off from SWIFT (the global financial messaging system that clears trillions of dollars per day) would be a serious escalation that would cripple Russian banks and be costly for foreign banks with investments in the country.[19]

Government limitations

There are strong shared interests in cyberspace at the international level, primarily focused on maintaining operational stability, but there are also conflicts of interest and areas where government power is limited. Cyber security has characteristics that set it apart from traditional security and defence, making it both interesting and difficult. It is difficult for governments to accept that they are not always the most powerful actor, and that they must rely on the private sector to gain better situational awareness or to access skilled people and innovative technologies.

Governments and companies have access to different pieces of the cyber security puzzle, such as network traffic, threat intelligence or human resources, which they sometimes share with each other in private forums. This sharing can be mutually beneficial, but the essential ingredient—trust—is hard to build and easy to destroy. Information-sharing is most effective when there are common mutual interests, when cooperation is narrowly focused and limited in duration, or when cooperation is based on long-standing trust and the number of participants is limited.

In the wake of the Snowden revelations, which revealed large-scale internet data monitoring and collection by the US and Western allies, many companies have reduced their level of information-sharing with the US government and distanced themselves from political partnerships that now appear toxic.[20] They have done this in an effort to salvage their reputation with current and potential international customers. International markets represents the majority of future growth potential for many US technology companies, and they cannot afford for their products to be compromised (or appear to be compromised).

Government limitations also extend to scale, people and buying power. For example, a large multinational manufacturing or defence company could easily have more (defensive) cyber security capability (in terms of people, process and technology) than many medium-sized countries. The people component is particularly crucial. Many governments struggle to attract and retain talented cyber security experts, and are forced to compete with the private sector for scarce talent. Few governments are capable of matching the US, which has the resources to supplement their cyber defence and intelligence agencies (such as the National Security Agency) with large and expensive contractor workforces.[21]

Government buying power in cyber security is also limited, relative to what they are accustomed to in traditional areas of security and defence. Militaries are the dominant buyers of submarines, warplanes and aircraft carriers, but for technology companies that sell hardware and software to a global market, even a government such as that of the US, Germany, or Japan is a minor player.

For example, the largest employer in the US is the Department of Defense with approximately 3.2 million civilian and military staff. But the Pentagon would have no hope making a bulk purchase and persuading Apple to produce an extra-secure version of the iPhone for all those employees. After all, in the final quarter of 2014, Apple sold approximately 65 million iPhones worldwide.[22] On occasion, governments can entice companies to produce specialised hardware or software, but this tends to be niche and highly expensive in the initial stages, with additional cost for upgrades and maintenance.

The international situation

> *The beautiful dream of the internet as a totally ungoverned space was just that—a beautiful dream. Like all utopian visions, it was flawed because it failed to account for the persistence of the worst aspects of human nature.*
>
> —Sir Iain Lobban, former Director of GCHQ[23]

The internet grew dramatically in the 1990s, propelled by the popularity of the web. This allowed online commerce to become commercially viable and cyber security rapidly became a topic of discussion. This happened particularly quickly in the US, which had a robust telecommunications network and had been developing precursors to the internet for several decades. Secure communications (enabled by encryption) had been the preserve of governments for decades, and only came to prominence in the private sector when online financial transactions (or 'e-commerce' as it was then called) were enabled by the growing popularity of the internet.[24]

In those early days the US controlled the basic protocols of the internet. Although some accommodation has been made since then, to account for the dramatic international growth of the internet, little has fundamentally changed. The US still retains a high level of influence over internet governance, even though the vast majority of internet users now reside outside of North America.[25]

Governance

Despite strong US influence, internet governance is gradually becoming more internationally representative. One example is the domain name system (DNS), which is the internet version of a telephone directory, and of which the US is slowly relinquishing control.[26] This has happened as governments around the world realise they need to become involved in discussions over the economic, social and political implications of internet connectivity. Global interest in the technical aspects of internet governance has also increased, largely due to the Snowden revelations, which demonstrated that US intelligence agencies has been using (and, in the opinion of many, abusing) the technological advantages enjoyed by the US.

Countries such as India and Brazil are becoming more assertive and there are a number of undecided 'swing states' that are yet to choose which governance model best fits their national interests—liberal, authoritarian, or something in the middle.[27] Russia and China are attempting to provide a counterweight to the political dominance over the internet of the US and Western Europe. However, their progress has been limited, and they have had difficulty gathering and maintaining international consensus and deciding on the most effective international body to use as a vehicle for their authoritarian vision of internet governance.[28]

High-level changes to the way the internet works (both governance and technical standards) take years to discuss, agree and implement, and are guided by economic and political priorities. There is more scope for action at the national level, for example with government filtering or censoring of internet traffic. In many cases these actions force users to provide their real names with email and social media accounts, sacrificing the freedom (through anonymity) that the internet has historically facilitated.[29] These actions are focused on imposing domestic control, but at the international level there is significant ambiguity regarding the actions of government.

Ambiguity and mistrust

It is extremely difficult to attribute online actions such as theft, disruption, espionage or sabotage to specific actors or groups with the same level of confidence that is possible in the physical world. There are many shades of grey in determining attribution, despite significant investments to do so by governments, companies, and security researchers.[30] This ambiguity presents opportunities for misdirection and misunderstanding, it has the potential to create and perpetuate mistrust, and complicates any attempts to codify international political agreements related to cyber security.

The current high levels of ambiguity in cyberspace (which is in the interests of many governments to maintain) mean that deterrence is a significant challenge. How can an attacker be deterred if their identity or affiliation is unknown? And what options does a government have if an adversary uses proxy actors such as individual hackers or organised criminals to launch attacks? When malicious software can be encrypted and transmitted online, or transported via a flash drive, what hope is there for traditional methods of monitoring and verification?

The Wassenaar Arrangement is one potential method for controlling the sale of software—such as surveillance packages or cyber attack tools—that is deemed to be dangerous in the wrong hands. The Arrangement is a voluntary, multilateral export control regime whose 41 member states exchange information on the transfer of arms and dual-use goods and technologies in an effort to improve national and international security and stability. In 2015, the US attempted to expand these export controls to include 'intrusion software', but the broad wording caused widespread concern in the cyber security and technology sectors, as it had the potential to encompass legitimate technologies and practices that are essential for robust cyber security.[31] Compared to export controls for missile technology and advanced materials processing, the control of software appears far more daunting and, in some instances, completely impractical.

The effects of digital disruption increase as a country becomes more connected, and this could plausibly create its own deterrent effect. For countries whose critical infrastructure is highly dependent on digital connections around the globe, the costs of mutual disruption may be sufficient to deter hostile action. This deterrent effect is more applicable at the government level, for policy-makers who have to consider the safety and stability of an entire country. Individual hackers and organised criminals have no such responsibilities and other incentives must be found to restrain their actions.

Attribution does not need to be iron-clad to formulate policy responses to undesired action. There are parallels with other areas of national security policy, such as the varying levels of attribution needed to take action related to arms trafficking or proliferation of weapons of mass destruction. If attribution can be improved through advanced technical means and supplemented by other intelligence and policy tools, then deterrence is not hopeless and there may even be the possibility of developing bi- or multilateral mechanisms that increase stability in cyberspace.

The development of cyber security treaties is still a long way in the future. Currently, there are high levels of mistrust—between the US and European democracies on one side, and Russia and China on the other side. From a national security perspective, there are limited incentives to cooperate or share sensitive information with nations that are not close allies.[32] It remains in the interest of many powerful states for power to be projected ambiguously in cyberspace, and it is almost inconceivable that they would restrain themselves through treaty obligations.

There is no international consensus (nor is there likely to be) on issues of national sovereignty such as intelligence gathering and surveillance of domestic populations. There is little agreement over the application of international law and what constitutes use of force in cyberspace, however the NATO-led publication of the *Tallinn Manual on the International Law Applicable to Cyber Warfare* represents a significant though non-binding set of perspectives widely shared among NATO partners.[33] Neither Russia nor China have offered a similarly considered viewpoint of their own.

There is no adequate solution to these challenges and this has motivated governments to invest in the development of normative structures in the form of confidence building measures (CBMs), which can be designed for various purposes, for example:

- *Crisis management:* to establish lines of communication during or after an incident
- *Restraint:* to identify actors that have protected-status during conflict
- *Collaboration:* to bring actors together to adapt and apply existing norms;
- *Engagement:* to bring neutral actors together to establish new norms of behaviour and strengthen the stability of the internet.[34]

A series of international conferences—beginning in London in 2011—provided a high-profile forum to pull together major governments and companies to discuss CBMs and norms of behaviour in cyberspace.[35]

The international community, including the public and private sectors, has shown itself capable of cooperating on some common problems. The 2004 Budapest Convention on Cybercrime was a significant step forward in harmonising cyber crime laws and increasing international cooperation between law enforcement agencies on 'infringements of copyright, computer-related fraud, child pornography and violations of network security'.[36] However, both the development of CBMs and collaboration to address common problems tend to be incremental and long-term processes, disrupted regularly by geo-political disagreements and unresolved tensions. Progress is likely to be measured in decades.

Threat inflation

As the existential threat posed by nuclear conflict receded with the end of the Cold War, national security priorities—particularly in the West—have focused on more diffuse threats such as terrorism, the internationally destabilising effects of localised conflicts, and cyber security. These threats offer plenty of scope for rhetorical inflation or exaggeration by policy-makers or vendors in search of a sale, and cyber security is no exception.

A certain amount of hyperbole is evident in the stories of pending 'cyber catastrophe', and news headlines that equate defacement of websites with warfare, when in reality the defacement is equivalent to graffiti.[37] With minimal investigation, it often becomes evident that the messengers of doom have much to gain from focusing on worst-case scenarios or stereotyped adversaries. On occasion the evidence resembles a Cold War-style 'missile gap' that systematically overestimates the capabilities of adversaries.

Government evidence to support the likelihood of worst-case scenarios tends to be sparse and uninformative due to concerns around national security or intelligence 'sources and methods'. Evidence from cyber security and forensic companies can be slightly more useful but often doubles as a marketing campaign and should be closely scrutinised.

It is worth noting that the top policy positions in many governments—particularly security and defence—are filled by former cold warriors whose professional experiences and perspectives were shaped by the dominant conflict of the past 70 years. Cyber security is relatively new compared to most security and defence topics, and it is not always straightforward to understand where it is appropriate to draw parallels with past conflicts and where hyperbole is distorting the policy-making process. Analogies of nuclear deterrence, disarmament and non-proliferation are often used inappropriately, neither accounting for the unique technical challenges of cyber security nor the vast difference between nuclear holocaust and digital disruption.

Possible futures

When the building blocks of cyberspace are identified and their characteristics are understood, it is possible to look into the future and assess how this environment could evolve. While it is difficult to make predictions with any certainty, there are some useful indicators.

The number of connected users is growing steadily and is one primary indicator of digital growth. Between the early 1990s (when the web was launched) and 2015, nearly 40 per cent of the world's population has connected to the internet.[38] It is a certainty that, within the next generation, most of humanity will have access to the internet through a PC, mobile device, wearable computer, or something yet to be conceived. And it is not just people communicating across the internet, it is also devices communicating with each other and with people. These devices will increase exponentially and by 2020 there will be an estimated 50-75 billion devices connected to the internet.[39] The data generated by these devices will help us to better understand our world but will also have to be carefully managed and secured.

Commercial trends will continue to shape the digital world as advances are made in connectivity, speed and storage. Computing power will continue to increase steadily, providing new opportunities for all actors, whether malicious and benign. Miniaturisation will allow smartphones and other computing devices to be packed with more sensors that interact with their environment and generate vast quantities of data.

Cyber security will grow in importance as dependence grows on a digital environment that is now essential to much of the world's population. It will be possible to connect nearly anything to the internet, and to use software to replace mechanical processes (such as in cars or factories).

Risk management will be more difficult for both the public and private sectors, given increasing levels of interconnection and complexity that conceals risks. When disruption occurs—either intentional or accidental—it will produce cascading effects that ripple through other sectors, with second and third-order consequences that will be nearly impossible to predict. Given such a high level of uncertainty, resilience will become more important and investments will be made in significantly strengthening the governance and technical foundations of the internet.

The majority of major technology companies have emerged from the West, although this is rapidly changing as Chinese technology, online commerce, and smartphone companies are expanding abroad and providing genuine competition for the incumbents. The motivation to expand internationally will result in increased tensions, as governments force domestic companies to share (internationally-gathered) information for law enforcement or national security purposes.

This dilemma has persisted in the US and UK for some time. It will be replicated in China, where domestic companies with international ambitions and significant resources will find themselves at odds with the national security priorities of an increasingly assertive Beijing. Customer pressure will factor into this as well. Multinational technology companies (such as Facebook, Google, and Alibaba) will be caught between law enforcement demands from countries where they do business, and the growing desire of users for more privacy and control of personal data.

Following the Snowden revelations, the loss of trust between the US Government and US-based technology companies will continue. This is one indicator of the espionage-related international tensions that will increase as governments around the world invest in a variety of capabilities related to digital offence and defence. Internet governance will be hard-pressed to stabilise this environment and, if the last decade is indicative of the next one, progress will be limited to gradually establishing norms, codes of conduct, and CBMs.

Conclusion

Security problems have inevitably arisen as the internet became the central nervous system of the globe, but these challenges must be viewed in the context of all positive changes that have emerged. The internet has empowered individuals around the globe, unleashed unprecedented levels of innovation and creativity, and created new markets while disrupting old ones. This capacity for disruption is a 'feature, not a bug, i.e. an intentional facility, not a mistake' in the design of the internet, and it benefits all users.[40]

Attention on cyber security will continue to grow as dependence on digital networks increases. These are risks that must be managed, not exaggerated. One sign of a mature digital environment will be when these risks are managed in the same way as other economic, social, and political risks that humanity has adapted to over the centuries. That maturity is a long way off, and between now and then there is still much work to be done harnessing the opportunities of cyberspace while understanding and minimising the dangers.

The views and opinions expressed are the author's own, as are any inaccuracies in fact or interpretation.

Endnotes

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The evolving framework of international treaties and agreements provides an essential tool for overcoming global security challenges. The implementation and verification of these arrangements builds confidence and know-how, allowing the international community to work cooperatively toward mutual goals. Informed and innovative approaches to verification and implementation that draw on technical, legal, political and economic insights will help to strengthen and sustain this framework. *Verification & Implementation* brings together leading practitioners and experts from the field to explain, appraise and propose ideas for strengthening the verification and implementation mechanisms that make international arrangements work in practice.