Nuclear Verification in a Middle East WMD Free Zone

Lessons from Past Verification Cases and Other Precedents

John Carlson

MIDDLE EAST WEAPONS OF MASS DESTRUCTION FREE ZONE SERIES

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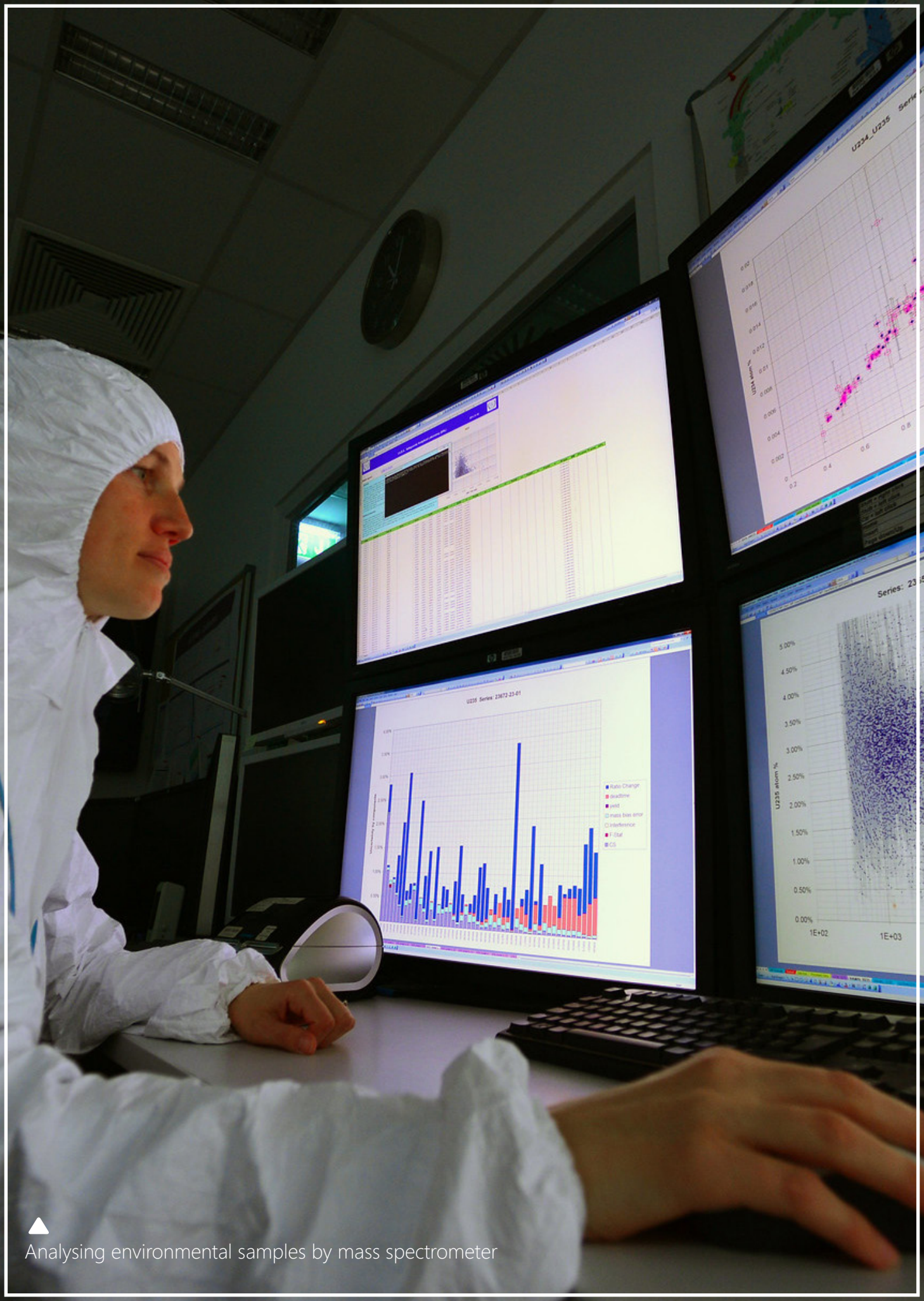
ABBREVIATIONS

ABACC	Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials
AFCONE	African Commission on Nuclear Energy
AP	Additional Protocol
CSA	comprehensive safeguards agreement
CTBT	Comprehensive Nuclear-Test-Ban Treaty
CWC	Chemical Weapons Convention
EIF	entry into force
EU	European Union
Euratom	European Atomic Energy Community
HEU	high enriched uranium
IAEA	International Atomic Energy Agency
IMS	International Monitoring System
JCPOA	Joint Comprehensive Plan of Action
LEU	low enriched uranium
NATO	North Atlantic Treaty Organization
NNWS	non-nuclear-weapon state
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
NWFZ	nuclear-weapon-free zone
NWS	nuclear-weapon state
R&D	research and development
SESAME	International Centre for Synchrotron Light for Experimental Science and Applications in the Middle East
SQP	small quantities protocol
TPNW	Treaty on the Prohibition of Nuclear Weapons
UNSC	United Nations Security Council
WMD	weapons of mass destruction



Analysing environmental samples by mass spectrometer

Dean Calma / IAEA

EXECUTIVE SUMMARY

Verification will be of critical importance to achieving and maintaining a Middle East zone free of weapons of mass destruction. In view of the high levels of tension and mistrust within the zone, ensuring effective verification will be especially demanding. This paper focuses on the nuclear aspects of such a zone. The paper is written in terms of a nuclear-weapon-free zone, but it envisages there would be complementary arrangements dealing with other weapons of mass destruction.

The primary purpose of verification in a nuclear-weapon-free zone is to provide assurance that nuclear material and activities in the zone are used for exclusively peaceful purposes and not for the manufacture of nuclear weapons. To ensure the effectiveness of the zone, in addition to manufacturing nuclear weapons, other prohibitions, all of which could be covered by appropriate verification arrangements, should include prohibition of research and development for nuclear weapons, possession of nuclear weapons, stationing of nuclear weapons, and nuclear testing. Prohibition of possession of nuclear weapons points to the need for arrangements for the elimination of nuclear weapons where these exist in the region.

A number of existing treaties and arrangements can be drawn on in developing verification for a Middle East nuclear-weapon-free zone. These include, at the global level, the Treaty on the Non-Proliferation of Nuclear Weapons, International Atomic Energy Agency (IAEA) safeguards, and the Comprehensive Nuclear-Test-Ban Treaty and, at a regional level, the five regional-based nuclear-weapon-free zone treaties, in particular the African Nuclear-Weapon-Free Zone Treaty, which applies to almost half the prospective parties to a Middle East zone, and the Islamic Republic of Iran Joint Comprehensive Plan of Action.

The IAEA has played a key role in verifying all the above-mentioned treaties and arrangements (other than the Comprehensive Nuclear-Test-Ban Treaty) and should certainly do so in any future Middle East nuclear-weapon-free zone. The IAEA's comprehensive safeguards system has operated for almost 50 years. The system has faced a number of major challenges, particularly from states in the Middle East, and has been substantially strengthened in response to those challenges, as exemplified by the IAEA's 1997 Model Additional Protocol. On verification of nuclear disarmament, the IAEA's experience with South Africa provides important lessons to draw on.

While the IAEA will have a central role in verification, a regional verification system with an emphasis on mutual inspections can make a major contribution to building trust, capacity and confidence among the parties.

Nuclear latency – the development of capabilities that could enable a state to produce nuclear weapons should it decide to do so – is the single most difficult challenge facing a prospective Middle East nuclear-weapon-free zone. Experience with the

Islamic Republic of Iran Joint Comprehensive Plan of Action illustrates the complexities of dealing with nuclear latency through verification. As will be discussed, the ability to provide *timely warning* of misuse of nuclear materials is an essential aspect of providing credible assurance of peaceful use. However, timely warning might not be possible if a state has latent capabilities. This means the parties to the prospective zone cannot rely on the existing safeguards measures alone but must be prepared to consider constraints on proliferation-sensitive activities, particularly enrichment and reprocessing, as an essential complement to the zone.

It may seem unrealistic to be discussing more rigorous nuclear verification in the Middle East, let alone constraints on sensitive nuclear activities, in today's regional circumstances. However, the states in the region cannot afford to ignore the difficult challenges facing them. If nothing changes, there is likely to be a regional race to establish, at the very least, nuclear latency. Such a race can only increase levels of tension and risk in the region.

It is essential not to think of verification in adversarial terms, as an external imposition on national sovereignty. Rather, verification should be seen as an expression of cooperation, of states working together for mutual benefit. Effective verification arrangements would serve a vital national security objective for each state in the region by reducing tensions, removing the motivation to proliferate, and mitigating the risk of a virtual nuclear arms race (or war). An agreement that can achieve this outcome between key parties in the region, such as Egypt, the Islamic Republic of Iran, Israel, Saudi Arabia, the Syrian Arab Republic and possibly Turkey, would be of enormous benefit to these states. Even if it is only possible to extend the agreement commitments to Israel progressively, such an agreement would represent a great achievement for the region.

The process of negotiating the details of the zone, which will require close engagement of policymakers, diplomats and experts, can itself help build regional confidence and trust. Where new verification measures are introduced, the collaboration required to develop these measures can also contribute to confidence-building. This is particularly the case with regional inspection arrangements, where time will be needed to develop the arrangements and the necessary expertise to implement them.

Nuclear issues cannot be considered in isolation, and similar work will need to be progressed with respect to the other weapons of mass destruction and delivery systems. All these subjects need to be pursued in the broader regional political and security context. An important step in this regard would be to revive discussions among the Middle East states on regional security structures.

1. INTRODUCTION

This paper discusses verification of the nuclear aspects of a future Middle East zone free of weapons of mass destruction (WMD). Owing to the differences in technologies, objectives and methodologies among the three categories of WMD – namely, nuclear, chemical and biological – as well as differences in the means of delivery, the paper addresses only the nuclear-weapon-free zone aspect, though it is expected that nuclear aspects will be one element (albeit a major one) in a zone treaty or treaties that will apply to all WMD and means of delivery.[1]

It is possible to develop a Middle East nuclear-weapon-free zone (NWFZ) in such a way as to serve the national interest of every Middle East state. If nothing is done, Middle East states are heading towards a race to develop *nuclear latency* – the capability of producing nuclear weapons – which could very well lead to a regional nuclear arms race, regional instability and the risk of nuclear war. No state stands to gain from such a situation. A NWFZ offers the best prospect of avoiding this outcome. However, existing international verification tools alone are not sufficient to address the challenge of latency; this will require additional political, legal and technology constraints and for each state to analyse its interests dispassionately. It is not productive for states to think in terms of preserving "rights" or avoiding constraints. Rather, each state should ask, What would it like to see apply to those states it considers to be a current or potential threat to its security? The state must appreciate that whatever measures it would like to see applied to others will have to be reciprocal.

Verification to provide assurance that treaty commitments are being met would have a critical role in any Middle East NWFZ. To provide the necessary assurance, verification must not only *be* effective but be *perceived* by the parties as being effective. If the parties do not believe that commitments adopted within the zone's legal framework are being verified effectively, they will not have the confidence needed to fully commit to the zone and its principles. Effective verification will require a significant level of on-site access by inspectors. It will be essential to gain acceptance of this by all parties. The parties must appreciate that a necessary degree of intrusiveness is essential for the zone to provide the degree of assurance they and the international community need. Each party will have to accept the same standard of verification that it wants to see applied to the other parties. Intrusiveness and national security are not mutually exclusive: appropriate security protocols can ensure the protection of national interests while at the same time supporting the achievement of regional objectives.

It is essential to think about verification in its broader political and security context. Verification should not be seen as an external imposition on national sovereignty. Rather, verification should be seen as an expression of cooperation, of states working together

1. Because of the complexity of dealing with all WMD, it is possible there could a separate treaty with respect to each category of WMD rather than a single treaty covering everything.

Once a cylinder's contents are verified, inspectors attach an IAEA metallic seal - commonly used to prevent tampering. The seals provide important evidence of any unauthorized attempt to gain access to the secured material.

D. Calma/IAEA

to enhance their own national security as well as for mutual benefit. Verification, if it is effective, will serve the vital national security interest of each party to the Middle East zone, by reducing regional tensions and reducing the threat that states in the region will pursue nuclear weapons and other WMD programmes.

The process of negotiating the details of the zone will require close engagement of policymakers, diplomats and experts. This in itself will contribute to building regional confidence and trust. Further, nuclear and other WMD issues should not be considered in isolation. It will be both timely and extremely helpful to revive discussions among the Middle East states on regional security arrangements.

The lessons learned from past verification cases need to be considered in the context of the objectives of this zone. Specific elements of the future zone, discussed in this paper, include:

- How should the zone be delineated? Which states should be included?
- What prohibitions and obligations should apply in the zone?
- How should these prohibitions and obligations be verified?
- How would elimination of nuclear weapons in the zone be achieved?
- On what basis would the zone treaty enter into force?

2. DELINEATING THE ZONE

There is no generally agreed delineation of the "Middle East" region. The working definition commonly referred to comes from the United Nations Secretary-General study (1990) *Effective and verifiable measures which would facilitate the establishment of a nuclear-weapon-free zone in the Middle East*. This definition comprises the 22 members of the League of Arab States together with the Islamic Republic of Iran and Israel (see Table 1). For the purposes of this paper, it is assumed that these states would constitute the membership and territorial extent of the proposed zone.

There have been suggestions for a zone of smaller extent, for example comprising those states having a border with Israel or Saudi Arabia, together with the Islamic Republic of Iran. This would constitute 14 states.[2] A smaller group like this would largely avoid an overlap with the African Nuclear-Weapon-Free Zone established by the Treaty of Pelindaba, though Egypt would be a party to both zones. However, this smaller group would exclude a number of states that have close political and cultural links to the Middle East and have nuclear programmes: Algeria, Libya and Morocco. There is no doubt the Middle East zone would benefit from the inclusion of these states. In addition to these states, including the remaining states from the League of Arab States, as suggested in the UN study of the zone, would bring diversity to the membership of the zone.

One significant state not included in the UN study's definition of the zone, but important in terms of the zone's objectives, is Turkey. In view of Turkey's close ties with the Middle East – historical, cultural, political, economic and strategic – there are strong reasons for having Turkey as a participant in the Middle East zone. Iranian officials have referred to Turkey as having strategic significance for the Islamic Republic of Iran,[3] a judgment borne out among other reasons by President Erdogan's remarks indicating an interest in nuclear weapons.[4] No doubt there are other Middle East states that view Turkey as strategically important. It is generally understood that Turkey does not wish to be party to any binding arrangements in the region, and the US nuclear weapons stationed there as part of NATO (North Atlantic Treaty Organization) arrangements would be an issue.[5] However, finding an appropriate mechanism for Turkey's involvement could be an important issue for the Middle East zone.

2. Suggested by, for example, Pierre Goldschmidt in Moving towards a WMD Free-Zone in the Middle East, 2020, unpublished manuscript. The 14 states are Bahrain, Egypt, the Islamic Republic of Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, the Syrian Arab Republic, the United Arab Emirates and Yemen. https://drive.google.com/file/d/1Xrh3gkgmCdrHC5hEabxjL1dWyGFaNNX0/view?usp=sharing

3. Personal discussions between Iranian officials and the author in the early 2000s.

4. President Erdogan is reported as saying in 2019: "Some countries have missiles with nuclear warheads, not one or two. But (they tell us) we can't have them. This, I cannot accept." See Erdogan Says It's Unacceptable That Turkey Can't Have Nuclear Weapons, Reuters, 4 September 2019, https://www.reuters.com/article/us-turkey-nuclear-erdogan/erdogan-says-its-unacceptable-that-turkey-cant-have-nuclear-weapons-idUSKCN1VP2QN.

5. C. Kane, Planning Ahead: A Blueprint to Negotiate and Implement a WMDFZ in the Middle East, Center for Nonproliferation Studies, 2015, https://www.nonproliferation.org/wp-content/uploads/2015/04/Planning_Ahead_WMDFZ.pdf, p. 10.

MOCHOVCE, SLOVAKIA
IAEA Safeguards inspectors and local workers in the reactor hall of the Mochovce Nuclear Power Plant

Dean Calma / IAEA

3. PROHIBITIONS & OBLIGATIONS APPLYING IN THE ZONE

3.1. Current treaties and other instruments relevant to the zone

International and regional treaties and obligations that are already implemented in parts or the whole of the proposed Middle East zone are outlined below (see also Table 1). Given these measures are implemented already, the obligations under the zone legally must not detract from or be weaker than existing measures but should treat these measures as a baseline to be built on.

TREATY ON THE NON-PROLIFERATION OF NUCLEAR WEAPONS

All states in the proposed Middle East zone except Israel are non-nuclear-weapon states (NNWSs) parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

The NPT has three fundamental pillars:

- Non-proliferation: NNWSs undertake not to seek or acquire nuclear weapons (article II). They are required to conclude agreements with the IAEA accepting safeguards on all their nuclear material to verify that they do not divert nuclear energy to nuclear weapons (article III.1).
- Disarmament: All parties undertake to pursue nuclear disarmament and general disarmament (article VI).
- Peaceful uses: The NPT is not to affect the right of the parties to develop research, production and use of nuclear energy for peaceful purposes provided this is in conformity with the treaty. All parties undertake to cooperate in the peaceful uses of nuclear energy (article IV).

The NPT sets out the fundamental obligation applicable to all states in the proposed zone, except Israel, not to seek or acquire nuclear weapons.

IAEA SAFEGUARDS AGREEMENTS

All states in the proposed zone that are parties to the NPT are required to conclude agreements with the IAEA accepting safeguards on all their nuclear material (that is, *comprehensive safeguards agreements*, or CSAs). All have done so except Somalia. This requirement does not apply to Israel as a non-party, but Israel has concluded an *item-specific* safeguards agreement applying to specified nuclear materials and facilities. IAEA safeguards are discussed in section 4 of this paper.

PELINDABA TREATY

The African Nuclear-Weapon-Free Zone Treaty, commonly referred to as the Treaty of Pelindaba, covers almost half the states expected to be included in a Middle East zone. Ten of the 24 prospective parties to the zone are situated in the area covered by the Pelindaba Treaty and are either parties to that treaty, have signed it or are expected to join the treaty in due course.

The African Nuclear-Weapon-Free Zone is one of five existing NWFZ treaties covering populated territories (see Table 2).[6]

The principal provisions of the Pelindaba Treaty can be summarized as follows:[7]

- Renunciation of nuclear explosive devices: the parties undertake not to conduct research on, develop, manufacture, stockpile or otherwise acquire, possess or have control over any nuclear explosive device (article 3).
- Prohibition of the stationing of nuclear explosive devices (article 4).
- Prohibition of nuclear testing (article 5).
- Verification of peaceful uses: nuclear activities are to be conducted for exclusively peaceful uses, verified through a CSA concluded with the IAEA (article 9).
- Elimination of any nuclear explosive devices: parties are required to declare any capability for the manufacture of nuclear explosive devices, dismantle and destroy any nuclear device, destroy manufacturing facilities or convert them to peaceful uses, and permit the IAEA to verify these actions (article 6).
- Prohibition of armed attacks on nuclear facilities (article 11).
- Clarification procedure: a party considering that another party is in breach of the treaty may seek clarification, including through technical visits, and may ask the African Commission on Nuclear Energy (AFCONE), established by the treaty, to request the IAEA to conduct an inspection; AFCONE may also establish its own inspection mechanism (annex IV).

These prohibitions are similar to those of the other NWFZ treaties, except for two provisions that are unique to Pelindaba: dismantlement of nuclear weapons (article 6), which reflects experience relating to the South African nuclear weapon programme (see discussion in Annex II of this paper), and prohibition of armed attacks on nuclear facilities (article 11), discussed in section 3.B.

6. Nuclear-weapon-free treaty obligations also apply to Antarctica, the seabed and outer space.
7. The Pelindaba Treaty also includes a mechanism for determining treaty compliance and provisions related to the structure and functions of the treaty organization (article 12; annex IV). However, these aspects are beyond the scope of this paper.

COMPREHENSIVE NUCLEAR-TEST-BAN TREATY

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) bans nuclear test explosions in any environment. It was adopted in 1996 but has still not entered into force. Pending the CTBT's entry into force (EIF), states that have ratified or signed the treaty have an obligation under the law of treaties not to act in any way that would defeat the CTBT's object and purpose.[8]

The CTBT has an exceptionally difficult EIF formula, requiring ratification by all 44 states named in annex 2 of the treaty. Currently, eight of the required 44 ratifications remain outstanding. Three of these are states in the proposed Middle East zone (Egypt, the Islamic Republic of Iran, and Israel); these states have signed the treaty but not yet ratified it.[9] Of the 24 prospective members of the Middle East zone, 15 states have ratified the CTBT and five have signed it.[10] The remaining four states have not signed the CTBT; the most significant of these, based on their current or proposed nuclear programmes, are Saudi Arabia and the Syrian Arab Republic.

Although the CTBT has yet to enter into force, key elements of the treaty's verification system – the International Monitoring System (IMS) – have been brought into provisional operation. Ten states in the proposed Middle East zone are designated to host IMS facilities, sharing monitoring data in accordance with the treaty. Six of these states[11] have met all the technical and operational requirements for their designated facilities (the facilities have been "certified"); the other four states[12] have not yet reached this stage.

OTHER INSTRUMENTS

Other instruments relevant to nuclear verification in the proposed zone include the Joint Comprehensive Plan of Action (JCPOA)[13] and the Treaty on the Prohibition of Nuclear Weapons (TPNW).

The JCPOA, which was concluded between the Islamic Republic of Iran, the five permanent members of the United Nations Security Council (UNSC), Germany and the European Union, is not a formal treaty. However, a number of its provisions are legally binding by virtue of being in other agreements or through incorporation in

8. See J. Carlson, Comprehensive Nuclear-Test-Ban Treaty: Possible Measures to Bring the Provisions of the Treaty into Force and Strengthen the Norm against Nuclear Testing, Vienna Center for Disarmament and Non-Proliferation, 2019, https://vcdnp.org/ctbt-possible-measures-to-bring-the-provisions-of-the-treaty-into-force-strengthen-the-norm-against-nuclear-testing.
9. The other outstanding ratifications required for the CTBT's entry into force are those of China, India, the Democratic People's Republic of Korea, Pakistan, and the United States of America.
10. See Table 1.
11. Djibouti, Israel, Jordan, Kuwait, Morocco and Oman. See https://www.ctbto.org/tiles/pdf/CTBTO-Map-IMS-2020-10-07-All_Stations-Overview.pdf.
12. Egypt, the Islamic Republic of Iran, Libya and Saudi Arabia.
13. While the JCPOA provisions explicitly state they "should not be considered as setting precedents" (JCPOA paragraph xi), in practice the unique provisions of the JCPOA created an important set of tools that could provide valuable insights and lessons for a ME WMDFZ.

Inspectors taking a swipe sample at a nuclear facility.

IAEA Department of Safeguards

decisions of the UNSC. A number of the provisions in the JCPOA could be considered for application in the Middle East zone: see discussion in section 4.6 and Annex II, section B.

The TPNW entered into force on 22 January 2021, 90 days after the fiftieth state ratified it.[14] The treaty's provisions on safeguards and verification have been one of the main points of contention about the treaty.[15] Only one of the 24 states in the proposed Middle East zone has ratified the TPNW (the State of Palestine), four have signed but not ratified it,[16] and 15 states that voted for adoption of the treaty text in the United Nations General Assembly have not signed it. Israel voted against the treaty, and the three remaining states did not vote.

3.2. What prohibitions and obligations should apply in the zone?

As a minimum, the prohibitions and obligations to apply within the zone should not detract from existing prohibitions and obligations, outlined in section 3.1. Rather, the existing prohibitions and obligations should be taken as a starting point and built on. As has been noted, these existing prohibitions and obligations do not currently apply to all the states in the proposed zone.

14. For the status of the TPNW, see https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVI-9&chapter=26&clang=_en.
15. J. Carlson, The 2020 NPT Review Conference and the TPNW Factor, International Luxembourg Forum, 2019, http://www.luxembourgforum.org/media/documents/Arms_control_Burden_of_change_2019_preview1.pdf.
16. Algeria, the Comoros, Libya and the Sudan.

The Treaty of Pelindaba is representative of the existing NWFZ treaties, and this treaty applies to almost half the prospective parties to the Middle East zone. Accordingly, it seems appropriate to take Pelindaba as representing the minimum prohibitions and obligations to be included in a Middle East NWFZ treaty and to update or extend these as necessary.[17]

APPLYING EXISTING PROHIBITIONS AND OBLIGATIONS THROUGHOUT THE ZONE

Drawing from the Treaty of Pelindaba, the following prohibitions and obligations should be included in the Middle East zone treaty. Depending on how Israel will be brought into the zone treaty (i.e. whether it is agreed that some of the treaty provisions would apply to Israel progressively, not until it disarms, or not until it disarms and joins the NPT), the provisions may need to be qualified in the case of Israel (for further discussion see section 5).

Renunciation of nuclear explosive devices: the parties undertake not to conduct research on, develop, manufacture, stockpile or otherwise acquire, possess or have control over any nuclear explosive device

Similar prohibitions apply under the NPT, but the language in the NPT is not as extensive as in the Pelindaba Treaty. The Pelindaba Treaty expanded on the NPT prohibitions by explicitly prohibiting research and development (R&D) on nuclear weapons.[18] Inclusion in the Middle East zone treaty of text similar to the Pelindaba provision will be an improvement on the NPT language. The zone treaty negotiators may wish to expand on R&D aspects, perhaps along the lines of the JCPOA; this is discussed in section 4.6 and Annex II, section B.

Prohibition of the stationing of nuclear explosive devices

Stationing refers to hosting nuclear weapons that are under the control of another state. This prohibition is included in the Pelindaba Treaty and in the TPNW; the NPT has no equivalent provision. Inclusion in the Middle East zone treaty of text similar to the Pelindaba provision will be required for consistency with Pelindaba and would be an improvement on the NPT.

Currently, US nuclear weapons are stationed in Turkey under NATO arrangements. A prohibition on stationing of nuclear weapons will affect Turkey if it is party to the zone. Meanwhile, there has been speculation that Pakistan might deploy nuclear-armed forces in Saudi Arabia if the Saudis found themselves in extremis.[19] A prohibition on stationing would make this illegal.

17. Given the overlapping membership between Pelindaba and the proposed Middle East treaty, it will also be necessary to develop arrangements for how the two treaties and their organizational arrangements will interact.
18. A prohibition on use of nuclear material in nuclear weapon R&D is implicit in the NPT through the requirement for nuclear material to be used for peaceful purposes under IAEA safeguards. R&D aimed at the development of nuclear weapons cannot be regarded as peaceful, and such R&D indicates an intention to use nuclear material at some point. The reference in article III.1 of the NPT to "diversion of nuclear energy from peaceful uses to nuclear weapons" indicates that the treaty's peaceful use obligation is not limited to nuclear material.
19. T.W. Lippman, Nuclear Weapons and Saudi Strategy, Middle East Institute, Policy Brief No. 5, 2008, https://www.mei.edu/sites/default/files/publications/Lippman.pdf.

Prohibition of nuclear testing

This prohibition is included in the Pelindaba Treaty, as well as applying to all states that have ratified or signed the CTBT. As noted above, pending the CTBT's EIF, the prohibition on testing applies to states that have ratified or signed the CTBT through the general law of treaties. As shown in Table 1, four states in the proposed Middle East zone have not yet signed the CTBT.

The prohibition on nuclear testing should be included in the zone treaty. In addition, it is suggested that the zone treaty should require, like the Treaty of Semipalatinsk, that all parties ratify and act in accordance with the CTBT.[20] This would mean that the zone parties would commit to establishing the IMS facilities designated for their territory and transferring the data from these systems as provided under the CTBT. If the CTBT is not yet in force, the zone parties should consider asking the CTBT Organization to implement and verify the "no testing" component of the zone on a regional basis.

Verification of peaceful uses: nuclear activities are to be conducted for exclusively peaceful uses, verified through a CSA [and Additional Protocol] concluded with the IAEA

Currently, the obligation to conclude a safeguards agreement with the IAEA on all their nuclear material applies to all prospective zone parties, except Israel, through their membership of the NPT. The Pelindaba Treaty reiterates this obligation for the states that are parties to that treaty, referring specifically to a CSA.

It is suggested that the zone treaty should emulate the Treaty of Semipalatinsk and require all parties to also conclude an Additional Protocol (AP) with the IAEA. This is discussed in section 4.

Elimination of any nuclear explosive devices: parties are required to declare any capability for the manufacture of nuclear explosive devices, dismantle and destroy any nuclear device, destroy manufacturing facilities or convert them to peaceful uses, and permit the IAEA to verify these actions

This prohibition is included in the Pelindaba Treaty and therefore should also be included in the Middle East zone. The NPT has no equivalent provision, requiring only that the parties pursue negotiations in good faith on effective measures relating to nuclear disarmament.[21] Currently, Israel is the only state in the zone believed to have nuclear weapons. The elimination of nuclear weapons is discussed in section 5.

20. The Semipalatinsk Treaty does not expressly require its parties to ratify the CTBT, as all had done so before the Semipalatinsk Treaty was negotiated. Article 5 of the Semipalatinsk Treaty requires the parties to act in accordance with the CTBT.
21. NPT, article VI.

Prohibition of armed attacks on nuclear facilities

This prohibition is included in the Pelindaba Treaty; the NPT has no equivalent provision. To date, the Pelindaba Treaty is the only NWFZ treaty to prohibit attacks on nuclear facilities. Article 11 of the treaty prohibits parties from undertaking, assisting or encouraging armed attacks on nuclear installations within the African Nuclear-Weapon-Free Zone. Given that the Pelindaba Treaty applies to almost half the prospective parties to a Middle East NWFZ, it is appropriate that the Middle East NWFZ treaty should also prohibit such attacks.

As a military attack on a nuclear facility does not necessarily entail use of a nuclear weapon, it might be asked whether this is an appropriate subject for inclusion in a treaty prohibiting nuclear weapons. A NWFZ treaty need not be limited to nuclear weapons; the parties are free to cover whatever issues they choose. The consequences of an attack on a nuclear facility could be similar to the use of a nuclear weapon, namely widespread radioactive contamination resulting in indiscriminate impact on civilians and the environment, and potentially extending well beyond the targeted state.

The issue of attacks on nuclear facilities is of particular concern to the Middle East in view of (a) the close proximity of many states and (b) the history of the Middle East as the only region where such attacks have occurred.[22] Fortunately, none of these attacks resulted in significant radiation releases. The Islamic Republic of Iran proposed a prohibition on armed attacks on nuclear facilities in the 1990 NPT Review Conference, and the IAEA General Conference adopted a resolution to this effect also in 1990. The Islamic Republic of Iran has continued to pursue this issue.[23] The Action Plan from the 2010 NPT Review Conference included such a prohibition.[24]

Given the time required for negotiating the zone treaty, another approach for the prohibition of attacks on nuclear facilities is for prospective zone parties to establish this prohibition in advance of the Middle East NWFZ. This would be an important confidence-building measure, contributing to a positive atmosphere for the negotiation and implementation of the NWFZ. The Agreement on the Prohibition of Attack against Nuclear Installations and Facilities concluded between India and Pakistan in 1988 could provide a useful model. The prohibition could be

22. In 1980, Iranian aircraft attacked Iraq's Osirak research reactor, then under construction. In 1981, Israeli aircraft destroyed the Osirak reactor. From 1984 to 1987, during the Iran-Iraq War, Iraq launched several air strikes on the Islamic Republic of Iran's two Bushehr power reactors, then under construction, causing major damage. In 1991, Iraq unsuccessfully targeted Israel's Dimona reactor with Scud missiles. In 1991 and 1993, during the First Gulf War, the United States attacked the Tuwaitha research centre and other nuclear targets in Iraq. In 2007, Israeli aircraft destroyed a suspected reactor under construction at Al-Kibar, Syrian Arab Republic. The most recent examples involved non-state actors: In July 2014, Hamas launched unsuccessful rocket attacks against Israel's Dimona reactor, and in 2017 Yemen's Houthi rebels claimed they had fired a cruise missile at the nuclear plant under construction in Abu Dhabi, United Arab Emirates.
23. Nuclear Threat Initiative, Iran Urges IAEA Members to Ban Attacks on Nuclear Sites, 13 August 2009, https://www.nti.org/gsn/article/iran-urges-iaea-members-to-ban-attacks-on-nuclear-sites.
24. 2010 NPT Revcon Action Plan, action 64, see page 29 of https://www.nonproliferation.org/wp-content/uploads/2015/04/2010_fd_part_i.pdf.

incorporated into the NWFZ treaty when this is negotiated, or it could continue as a stand-alone instrument.

Clarification procedure

This mechanism for clarifying possible treaty violations is discussed in section 4.7.

SUGGESTED ADDITIONAL PROHIBITIONS AND OBLIGATIONS: PROHIBITION OF ENRICHMENT AND REPROCESSING

It might be necessary to consider measures beyond those included in the Pelindaba Treaty. Many may question the need or reason for going beyond existing common prohibitions. Doing so is warranted by the high level of political and military tension that exists among the states in the region, as demonstrated by the number of these states that have pursued nuclear weapons in violation of their NPT obligations.

Some may question the use of the term *prohibition* in relation to enrichment and reprocessing, which legally and historically have been considered legitimate fuel cycle activities under the NPT. In more recent times, however, the implications for the non-proliferation regime of national enrichment and reprocessing programmes have come under increasing scrutiny. Enrichment and reprocessing activities are dual-use technologies that can provide a state with the possibility of manufacturing nuclear weapons. As discussed in Annex I, nuclear latency has major implications for the ability of verification to provide timely warning of misuse of nuclear material and facilities. A NWFZ proposal that fails to deal with the challenge of nuclear latency will not succeed in providing the peaceful use assurances that the regional parties need.

Measures to limit or avoid latency, as in the JCPOA, might not be thought of as traditional verification measures, but latency has profound implications for the efficacy of verification. Rigorous safeguards measures could be put in place at enrichment plants and associated sites, but other states would be concerned whether they could be sufficiently effective. The potential breakout time would be so short that it would be extremely difficult for safeguards to provide timely warning.

For this reason, the negotiation of the zone will have to encompass measures that not only help ensure the zone is effectively verifiable but, importantly, strengthen the zone's capacity for confidence-building to address the prevalent mistrust. The most effective way of addressing the fundamental risks associated with dual-use technologies would be to make the zone free of all uranium enrichment and reprocessing. This would be a new measure, compared with existing NWFZs, but would reflect the threats present in the Middle East region.

Enrichment and reprocessing programmes are not only a problem for non-proliferation; they are also a complication in progressing global nuclear disarmament. The possibility of breaking out of treaty commitments could be just as tempting to a nuclear-armed state committed to reducing and eliminating nuclear weapons as to a NNWS. Thus, whatever approach is agreed for the Middle East zone could have wider precedential importance.

Broadly speaking, the options for dealing with the risks associated with enrichment and reprocessing in the Middle East zone are as follows:

Prohibit reprocessing

None of the countries in the prospective zone is known to have reprocessing capabilities for peaceful uses. Also, reprocessing is beyond the technical or economic needs of any future nuclear civilian programme in the region. Therefore, it should be possible to reach agreement to an unqualified prohibition on reprocessing.

The prohibition on reprocessing should also extend to the import and possession of separated plutonium. The objective of prohibiting reprocessing in the region is to ensure no state has separated plutonium available; the prohibition on reprocessing would be defeated if a state could import plutonium. For this reason, the import and use of mixed-oxide fuel[25] should be prohibited. There is no basis under any foreseeable circumstances to believe that plutonium fuels will be required by any state in the zone. Therefore, it is suggested that the prohibition on importing and possession of plutonium be unqualified (except, possibly, small quantities for scientific research).

Permit uranium enrichment for low enriched uranium, provided it is declared and operated under safeguards

Under this option, enrichment below 20 per cent U-235 (low enriched uranium – LEU) would be permitted. High enrichment, above 20 per cent U-235, would be prohibited as there is no legitimate need for the production of high enriched uranium (HEU) for civilian use.

If this option were adopted, states in the region could establish enrichment programmes that, despite the limitation to LEU, would give them the capability for rapid breakout to nuclear weapons (see Annex I). This could create a capability race, with a real risk of leading to a regional arms race. Overt enrichment operations, including the production of uranium hexafluoride feedstock and centrifuge components, training of personnel, and conduct of R&D, could also provide cover for parallel clandestine enrichment operations. For these reasons, permitting national enrichment programmes will be inherently destabilizing, undermining the trust and confidence that the zone is intended to provide.

If low enrichment were permitted, this could be qualified by specifying certain limits, such as the enrichment level, the scale of operations and the quantity of enriched stocks. This is the approach taken under the JCPOA. One option under this scenario is to limit enrichment to typical power reactor levels (say 5 per cent U-235). However, the production of LEU even at the lower end of the spectrum is problematic as the greatest enrichment effort is required to reach the first few

25. *Mixed-oxide fuel* is a mixture of oxides of uranium and plutonium. Mixed oxide fuel is a way of recycling plutonium separated from spent fuel by reprocessing.

percent enrichment.[26] This has similar problems to unrestricted low enrichment.

Another version of this option is to limit the scale of enrichment operations and the quantity of LEU stocks. This is the approach adopted under the JCPOA, with temporary limitations. It was intended that longer-term constraints would be negotiated. Maintaining a low level of operation indefinitely could be perceived as maintaining a latency option, which would be at odds with the purpose of the zone.

Prohibit all (national) enrichment activities

This approach would avoid the problems set out in the previous option. There would still be the possibility of a state pursuing a clandestine enrichment programme, but without a level of overt enrichment activity it would be more difficult to achieve breakout capabilities. To address concerns states with nuclear power programmes may have about security of fuel supply, internationally guaranteed fuel supply assurances, involving the current major enrichment providers, could be established in support of the zone.

Establish one or more multilateral approaches

If the zone treaty includes a prohibition on enrichment, it may be necessary to consider a multilateral approach, which would be greatly preferable to national programmes. A discussion of multilateral approaches is beyond the scope of this paper,[27] but such approaches could include:

- A regionally controlled fuel cycle centre
- Internationally guaranteed fuel supply assurances, obviating any need for enrichment in the region

Such a provision or measure is not included in the existing zone treaties, and if it were to be pursued in the Middle East zone, it may be addressed in a separate legal arrangement. However, the cost of establishing a major new enrichment centre would be very high, and it is doubtful it could be cost-effective. Issues to be addressed with a regional centre include how to ensure such a centre does not lead to dissemination of proliferation-sensitive technology and how to ensure the centre cannot be seized and misused by the host state.

26. As outlined in Annex I, almost 90 per cent of the enrichment effort required to produce weapon grade HEU is needed to reach 5 per cent U-235. Reaching weapon grade (say 90 per cent U-235) requires only incrementally more effort.
27. See J. Carlson, Iran and a New International Framework for Nuclear Energy, Belfer Center, Harvard Kennedy School, 2016, https://www.belfercenter.org/publication/iran-and-new-international-framework-nuclear-energy.

TABLE 1: Middle East NWFZ : Participation by prospective parties in nuclear treaties

	NPT	CSA	AP	PELINDABA TREATY	CTBT	TPNW
STATES WITH SIGNIFICANT NUCLEAR ACTIVITIES						
Algeria	✓	✓	*Signed*	✓	✓	*Signed*
Egypt	✓	✓		*Signed*	*Signed (1)*	
Iran, Islamic Rep.	✓	✓	(2)	*n/a*	*Signed (1)*	
Iraq	✓	✓	✓	*n/a*	✓	
Israel		*n/a*		*n/a*	*Signed (1)*	
Jordan	✓	✓	✓	*n/a*	✓	
Libya	✓	✓	✓	✓	✓	*Signed*
Morocco	✓	✓	✓	*Signed*	✓	
Saudi Arabia (3)	✓	Old SQP		*n/a*		
Syrian Arab Republic	✓	✓		*n/a*		
United Arab Emirates	✓	✓	✓	*n/a*	✓	
STATES WITHOUT SIGNIFICANT NUCLEAR ACTIVITIES						
Bahrain	✓	Revised SQP	✓	*n/a*	✓	
Comoros	✓	Revised SQP	✓	✓	*Signed*	*Signed*
Djibouti	✓	Revised SQP	✓	*Signed*	✓	
Kuwait	✓	Revised SQP	✓	*n/a*	✓	
Lebanon	✓	Revised SQP		*n/a*	✓	
Mauritania	✓	Revised SQP	✓	✓	✓	
Oman	✓	Old SQP		*n/a*	✓	
State of Palestine	✓	*Signed*		*n/a*		✓
Qatar	✓	Revised SQP		*n/a*	✓	
Somalia	✓	No CSA		*Signed*		
Sudan	✓	Old SQP		*Signed*	✓	*Signed*
Tunisia	✓	✓	*Signed*	✓	✓	
Yemen	✓	Old SQP		*n/a*	*Signed*	

KEY

✓	The state is a party to the treaty concerned.
AP	Additional Protocol.
CSA	Comprehensive safeguards agreement.
CTBT	Comprehensive Nuclear-Test-Ban Treaty.
n/a	The treaty is not applicable to this state.
NPT	Treaty on the Non-Proliferation of Nuclear Weapons.
Old SQP	Small quantities protocol, original version (1974). The SQP suspends operation of most CSA provisions; see section 4(c).
Pelindaba Treaty	African Nuclear-Weapon-Free Zone Treaty.
Revised SQP	Small quantities protocol, 2005 revision. Compared with the old SQP, this changes the eligibility requirements and reinstates CSA provisions.
TPNW	Treaty on the Prohibition of Nuclear Weapons.

NOTES

1. An annex 2 state, whose ratification is required for the CTBT to enter into force.

2. The Islamic Republic of Iran is implementing its AP provisionally.

3. Saudi Arabia is building a research reactor, is planning for several power reactors, and has expressed interest in uranium enrichment.

Cameras are often used to verify that no diversion of nuclear material takes place.

Dean Calma / IAEA

SOURCES	
AP	IAEA status report, 18 September 2020, https://www.iaea.org/sites/default/files/20/01/sg-ap-status.pdf.
CSA	IAEA Country Factsheets, https://www.iaea.org/resources/legal/country-factsheets, accessed 21 September 2020.
CTBT	Status of signature and ratification, https://www.ctbto.org/the-treaty/status-of-signature-and-ratification, accessed 21 September 2020.
Pelindaba Treaty	https://au.int/en/treaties/african-nuclear-weapon-free-zone-treaty-pelindaba-treaty, accessed 21 September 2020.
SQP Status	IAEA status report, 18 September 2020, https://www.iaea.org/sites/default/files/20/01/sg-sqp-status.pdf and the Safeguards Implementation Report for 2019, GOV/2020/9, 29 April 2020. The IAEA does not release the report publicly, but the text was leaked and is posted at https://armscontrollaw.com/2020/05/12/2019-iaea-safeguards-implementation-report.
TPNW	Status of signature and ratification, https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVI-9&chapter=26&clang=_en, accessed 11 November 2020.

TABLE 2: Existing regional NWFZ treaties

TREATY OF TLATELOLCO 1967	TREATY OF RAROTONGA 1985	TREATY OF PELINDABA 1996	TREATY OF BANGKOK 1995	TREATY OF SEMIPALATINSK 2006
Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean	South Pacific Nuclear Free Zone Treaty	African Nuclear-Weapon-Free Zone Treaty	Treaty on the South-East Asia Nuclear-Weapon-Free Zone	Treaty on a Nuclear-Weapon-Free Zone in Central Asia

TABLE 3: Summary of nuclear prohibitions and obligations expected in a Middle East WMD free zone treaty

PROHIBITIONS AND OBLIGATIONS	COVERED (PARTIALLY/ COMPLETELY) BY EXISTING LEGAL MANDATE	VERIFIED BY
Renunciation of nuclear explosive devices: the parties undertake not to conduct research on, develop, manufacture, stockpile or otherwise acquire, possess or have control over any nuclear explosive device	**NPT**, except for Israel **Pelindaba** for parties thereto Pelindaba is more explicit on prohibition of R&D	Mostly **IAEA** (but no routine coverage of dual-use areas not involving nuclear material)
Prohibition of the stationing of nuclear explosive devices	**Pelindaba** and TPNW for parties thereto	No established verification process
Prohibition of nuclear testing	**CTBT**, although not yet in force and not adopted by all regional states	**CTBT** Organization
Verification of peaceful uses: nuclear activities are to be conducted for exclusively peaceful uses, verified through a CSA and AP concluded with the IAEA	**NPT**, **CSA** and **AP**, except Israel	**IAEA**
Elimination of any nuclear explosive devices: parties are required to declare any capability for the manufacture of nuclear explosive devices, dismantle and destroy any nuclear device, destroy manufacturing facilities or convert them to peaceful uses	**Pelindaba** for parties thereto	**IAEA** conducted in the past under expanded mandate
Prohibition of armed attacks on nuclear facilities	**Pelindaba** for parties thereto	
Clarification procedure	**Pelindaba** for parties thereto	**AFCONE**, **IAEA**
Mechanism for determining treaty compliance	**NPT**, partly; **IAEA** safeguards agreements	**IAEA**, **AFCONE**
For consideration – Prohibition of enrichment and reprocessing		Potentially **IAEA** under expanded mandate

KEY	
AFCONE	African Commission on Nuclear Energy
AP	Additional Protocol
CSA	comprehensive safeguards agreement
CTBT	Comprehensive Nuclear-Test-Ban Treaty
IAEA	International Atomic Energy Agency
NPT	Treaty on the Non-Proliferation of Nuclear Weapons.
R&D	research and development
TPNW	Treaty on the Prohibition of Nuclear Weapons

Satellite Imagery facilities at the IAEA Department of Safeguards

Dean Calma / IAEA

4. VERIFICATION

As discussed above, owing to the high level of political and military tension among states in the Middle East region, it is essential for the zone treaty to be underpinned by effective verification measures, otherwise some parties may be tempted to cheat, and the zone will ultimately fail.

A further requirement, if the zone treaty is to be successful, is that in the event of a treaty violation, there should be effective enforcement action; this topic is beyond the scope of the present paper.

4.1 Key lessons from past verification cases

Key lessons for a Middle East zone from the cases discussed in Annex II can be summarized as follows:

- It is essential for all parties to an agreement to honour their commitments in good faith. This is *the* fundamental principle of international relations and will be absolutely essential if a Middle East zone is to be realized.

- All states benefit if the non-proliferation regime operates as intended. Major violations, however, will erode the trust and confidence that the regime seeks to provide within the regime and outside. No one will gain, and the Middle East zone will not be sustainable in such a case.

- The effective application of IAEA safeguards requires, at a minimum, implementation of a CSA and an AP. In the absence of an AP, the IAEA will not be able to conclude there are no undeclared nuclear materials or activities in the state concerned. Detection of undeclared nuclear activities is a major challenge, requiring verification at the highest level of effectiveness and, at times, intrusiveness. This depends on the ability of inspectors to access locations of interest and on the availability of necessary information, including information from the state itself, information collected and analysed by the verifying agency, and information provided by other states. While there has been some controversy over the use of information provided to the IAEA by third parties, such information-sharing is routine, a typical example being information on nuclear-related exports.

- It is essential for states to cooperate fully with the verification body on safeguards implementation. Failure to do so affects the ability of the IAEA and/or the regional body to meet their responsibilities and undermines international confidence in the state's commitment to its non-proliferation obligations. Cooperation and transparency will build trust and confidence.

- Where there are unfounded suspicions about a state, cooperation with the IAEA or

the regional body will provide the state the opportunity to resolve these suspicions. Obstructing inspectors has the opposite effect. Denying access and "sanitizing" sites will reinforce international suspicions that the state is hiding something. Serious non-cooperation, such that the verification body is *unable to verify that there has been no diversion of nuclear material to nuclear weapons*, is sufficient grounds for a non-compliance finding by the IAEA.[28]

- States should ensure they have an independent, competent and properly resourced national safeguards authority. This will enable good safeguards cooperation and avoid inadvertent breaches, which could fuel international suspicions.
- Mutual inspections can have important confidence-building benefits and can lead to broader transparency and collaboration among the states concerned.
- International cooperation is essential in dealing with safeguards violations; the IAEA is not an enforcement agency and depends on support from the UNSC.
- Where a major violation has been found or is suspected, the demand on the IAEA's resources can be substantial. For example, safeguards in the Islamic Republic of Iran currently account for some 15 per cent of the IAEA's global safeguards effort. This could have financial implications for zone parties: while IAEA costs are met by member states as a whole, the costs of a regional system would have to be met by the regional members.
- Verifying that a nuclear weapon programme has been dismantled and nuclear weapons eliminated will be resource intensive and take an extended period. Ultimately, a determination on the successful achievement of this task is likely to be based on expert judgment, taking into account factors such as cooperation, transparency, availability of information and consistency across an appropriately comprehensive range of information.

4.2 What can, and should, be verified in the zone?

The principal prohibitions and obligations that should apply in the zone are outlined above – see points in section 3.2 and Table 3. Each of these is currently being verified or can, from a technical perspective, be verified. As observance of each is fundamental to the objectives of the zone, it is essential that each is verified.

Some of these prohibitions are already covered by the IAEA within its current safeguards activities under CSAs and APs (discussed below), but others will require giving the verification entity, whether the IAEA or another organization, additional mandates and authorities.

IAEA safeguards will have a key role. It can be expected that IAEA safeguards will be

28. IAEA, 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, 1972, para. 19.

the basic foundation for nuclear verification in the zone – in the case of the NNWSs, through their CSAs and APs, and in the case of Israel, through arrangements to be negotiated (see section 5). In negotiating the verification of the nuclear prohibitions and constraints under the zone, questions to be resolved include the safeguards standard that will apply and whether IAEA safeguards will be complemented by additional confidence-building and transparency measures, possibly implemented by the IAEA or by a regional organization established for the zone.

The IAEA safeguards system has evolved over time in response to the various safeguards challenges that have emerged. Many of these challenges have come from states situated within the prospective Middle East zone. The key example is Iraq, where the discovery of a nuclear weapon programme led to the development of the IAEA's Model Additional Protocol for strengthening safeguards.[29] It is striking that four of the six historic cases of safeguards non-compliance have occurred within the Middle East region, as discussed in Annex II. This reflects the high level of tension and mistrust that exists in the region. It shows why a NWFZ is needed as a complementary measure to the NPT, and why the highest standard of verification must apply in the zone. The experience from these cases will need to be taken into account in the design and implementation of verification for the zone.

Different issues are raised with respect to Israel, which is not a party to the NPT and is generally believed to have nuclear weapons (Israel maintains ambiguity about this). Here, a major focus of verification would be to establish that all unsafeguarded nuclear activities in Israel have ceased and all its nuclear material is progressively placed under safeguards. The modalities for this have yet to be negotiated. Given the prevailing political situation in the region, realistically it can be expected that the Israel denuclearization process will require a phased approach over an extended period as discussed in section 5.

4.3 IAEA safeguards agreements

COMPREHENSIVE SAFEGUARDS AGREEMENTS

The NPT requires NNWSs to accept IAEA safeguards on all their nuclear material. The NPT provides (article III.1) that the purpose of these safeguards is to *verify a state's fulfilment of the obligations it has assumed under the treaty* with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices. Thus, the IAEA's safeguards system fulfils a vital role underpinning the NPT, reinforcing commitments to the non-proliferation of nuclear weapons and providing confidence that nuclear applications are used for exclusively peaceful purposes.

The safeguards agreements concluded pursuant to the NPT are commonly referred

29. IAEA, Model Protocol Additional to the Agreement(s) Between State(s) and the International Atomic Energy Agency for the Application of Safeguards document, INFCIRC/540(Corr.), 1997.

to as comprehensive safeguards agreements or CSAs.[30] All the states in the proposed Middle East zone have concluded CSAs with the IAEA, except Israel (which is not a party to the NPT), the State of Palestine (whose CSA has been approved by the IAEA's Board of Governors but has not yet been signed or brought into force), and Somalia.

The key objectives of IAEA safeguards under a CSA are the *timely detection* of the diversion of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other nuclear explosive devices or for purposes unknown, and *deterrence* of such diversion by the risk of early detection. Safeguards comprise measures to detect, identify, characterize and quantify nuclear material and to assess the peaceful nature of nuclear activities. These measures are applied by IAEA inspectors in cooperation with national authorities.

In the first two decades of IAEA safeguards pursuant to the NPT, safeguards procedures were primarily focused on nuclear facilities and other locations declared by a state. The possibility was recognized that a state might have *undeclared* nuclear materials and activities, but it was thought that other states, through *national technical means*, were better placed than the IAEA itself to find such violations. It was further thought that such states would inform the IAEA so inspectors could investigate.[31] The discovery of Iraq's nuclear weapon programme (see Annex II) was a major shock to the international community and the IAEA.[32] As a result, in 1992, the Board of Governors emphasized that the IAEA had the right and obligation under CSAs to verify not only that state declarations of their nuclear material holdings are *correct* (accurate) but that they are *complete*, that is, they include *all* the nuclear material in the state.

It became clear that to achieve this the IAEA had to improve its ability to verify *completeness*. The outcome was a major programme to strengthen the IAEA's safeguards system. The Model Additional Protocol, approved by the Board of Governors in 1997, is at the centre of this programme.

ADDITIONAL PROTOCOLS

The AP expands the IAEA's access rights to nuclear-related locations and widens the range of information states are required to provide to the IAEA. Other measures introduced to strengthen safeguards have included a central role for information collection and analysis to identify possible indications of undeclared nuclear activities; adoption of new technologies for improving detection capabilities; access rights for inspectors to a wider range of nuclear-related locations; greater unpredictability in safeguards inspections; and the development of a state-level approach that tailors safeguards implementation to state-specific circumstances. The latter measure moves away from the uniformity of traditional safeguards, instead basing safeguards intensity on the state's nuclear and nuclear-related activities and capabilities as a whole, within

30. CSAs were formerly known as *full scope* safeguards agreements.
31. For an early discussion of the completeness problem, see H. Gruemm, "Safeguards Verification – Its Credibility and the Diversion Hypothesis", IAEA Bulletin 25, no. 4, 1983, https://www.iaea.org/sites/default/files/publications/magazines/bulletin/bull25-4/25403452729.pdf.
32. In this case, national technical means had also failed. It was to become clear that detection of undeclared nuclear programmes required a collaborative effort between states and the IAEA.

the scope of the safeguards agreement.

By enabling the IAEA to obtain a much fuller picture of a state's current and planned nuclear activities, nuclear material holdings, and nuclear-related manufacture and trade, an AP increases the IAEA's ability to provide greater assurance of the absence of undeclared nuclear material and activities in the state.[33] This is reflected in the IAEA's annual safeguards conclusions for each state.

In connection with CSAs, the IAEA has three types of safeguards conclusion:

- For states with only a CSA in place, in the absence of an AP the safeguards activities that the IAEA may conduct for detection of undeclared nuclear material and activities are limited. If no evidence for diversion of declared nuclear material was detected, the IAEA can conclude that "all declared nuclear material remained in peaceful activities", but the Agency is not in a position to draw a conclusion about the absence of undeclared nuclear material and activities.

- For states with both a CSA and an AP in place, and where the IAEA has been able to carry out a comprehensive evaluation of all safeguards-relevant information available to it, including from safeguards activities pursuant to the AP, and has found no indications of undeclared nuclear material or activities in the state as a whole, the Agency concludes that all nuclear material in the state remained in peaceful activities. This conclusion is known as the *broader conclusion*.

- For states with both a CSA and an AP in place, but where the broader conclusion has not yet been reached, the Agency can conclude that all declared nuclear material remained in peaceful activities and note that evaluations regarding the absence of undeclared nuclear material and activities are ongoing.

ITEM-SPECIFIC SAFEGUARDS AGREEMENTS

An item-specific safeguards agreement[34] is the pre-NPT form of safeguards agreement, under which the IAEA applies safeguards only to materials and facilities specified in the agreement. This form of agreement continues to apply to states not party to the NPT. Israel is the only such state in the proposed zone. Under Israel's safeguards agreement, the IAEA applies safeguards to the United States-supplied research reactor and associated facilities located at the Soreq Nuclear Research Center.[35] Other nuclear materials and activities in Israel are not subject to safeguards. The IAEA has stated it is not in a position to provide information on unsafeguarded nuclear materials in Israel.[36]

33. For a detailed account of the development of the IAEA safeguards system, see J. Carlson, V. Kuchinov and T. Shea, The IAEA's Safeguards System as the Non-Proliferation Treaty's Verification Mechanism, Nuclear Threat Initiative, 2020, https://www.nti.org/documents/2646/NTI_Paper_Safeguards_FINAL_5-8-20.pdf.
34. Otherwise known as an *INFCIRC/66-type* agreement.
35. IAEA, IAEA Annual Report 2018: Additional Annex Information, GC(63)/5/Annex, 2019, https://www.iaea.org/sites/default/files/publications/reports/2018/gc63-5-annexinfo.pdf.
36. IAEA, Israeli Nuclear Capabilities, GOV/2010/49-GC(54)/14, 3 September 2010, https://www.iaea.org/sites/default/files/gc/gc54-14_en.pdf.

SMALL QUANTITIES PROTOCOL

While all NNWSs parties to the NPT are required to conclude CSAs, the majority of these states do not have significant nuclear activities. To avoid the burden on these states of unnecessary safeguards work, in 1974 the IAEA introduced the small quantities protocol (SQP) for states with quantities of nuclear material below those specified in the SQP and no nuclear material in a nuclear facility. The practical effect of these SQPs was to suspend most of the operative safeguards procedures, including inspections. This suspension applies unless and until the state concerned has acquired nuclear material above the specified quantities or introduces any quantity of nuclear material into a nuclear facility.

REVISED SMALL QUANTITIES PROTOCOL

In 2005, the IAEA revisited the SQP in recognition that, by suspending the safeguards procedures, these SQPs left the IAEA without the means to verify whether a state actually qualified for an SQP at the outset or whether it continues to qualify for an SQP. It is essential for the IAEA to be able, if considered necessary, to conduct inspections in an SQP state to establish whether the state has failed to declare nuclear materials or activities. The IAEA Board also considered it necessary to modify the eligibility requirements for a state to conclude an SQP.[37] Accordingly, in 2005 the Board approved a revised SQP, reinstating a number of the suspended procedures, and asked all states with SQPs to revise their SQPs accordingly or to rescind them where the state would no longer qualify for an SQP. Most have done so, but some old-form SQPs still exist. The IAEA has written to the states still with old-form SQPs, including Oman, Saudi Arabia, the Sudan, and Yemen in the prospective Middle East zone (see Table 1), asking them to adopt the revised SQP.[38]

4.4 Current status of safeguards application in the proposed Middle East zone

The status of safeguards application in the Middle East is notable for its unevenness (see Table 1). This would need to be addressed by the negotiators of the Middle East zone. Of the 23 prospective zone members other than Israel, there are nine variations of safeguards status:

- Ten states have a CSA and an AP in force (thus meeting the basic standard that should be set for the zone):
    - » Five of these states (Iraq, Jordan, Libya, Morocco and the United Arab Emirates) have significant nuclear activities (as defined by the IAEA).

37. The substantive change in the eligibility requirements was that, as from 2006, a state that has taken the decision to construct or to authorize the construction of a nuclear facility would no longer be entitled to conclude an SQP.
38. For the status of SQP adoption, see https://www.iaea.org/sites/default/files/20/01/sg-sqp-status.pdf.

  - » Five others (Bahrain, the Comoros, Djibouti, Kuwait and Mauritania) do not have significant nuclear activities.

  - » Of these ten states, the IAEA has drawn the broader conclusion for three (Jordan, Kuwait and Libya) but reported that for Libya it was unable to reach this conclusion in 2019.[39]

- One state (the Islamic Republic of Iran) has signed an AP and is implementing it provisionally.

- Two states (Algeria and Tunisia) have signed an AP but not yet brought it into force. Algeria has significant nuclear activities; Tunisia does not.

- Two states with significant nuclear activities (Egypt and the Syrian Arab Republic) have not taken steps to conclude APs.

- One state with significant nuclear activities (Saudi Arabia) maintains an old-form SQP under which most IAEA safeguards activities are suspended. Since Saudi Arabia is building a nuclear research reactor and is planning a substantial nuclear power programme, it will not qualify for the SQP once it acquires nuclear materials above specified quantities or introduces nuclear material into a facility. Further, Saudi Arabia has not taken steps to conclude an AP.

- Two states with no significant nuclear activities (Lebanon and Qatar) have the revised SQP, but no AP.

- Three states with no significant nuclear activities (Oman, the Sudan and Yemen) still have the old SQP and no AP.

- One state with no significant nuclear activities (the State of Palestine) has signed a CSA with a revised SQP but has not yet brought its CSA into force; it has not taken action to conclude an AP.

- One state with no significant nuclear activities (Somalia) has yet to conclude a CSA.

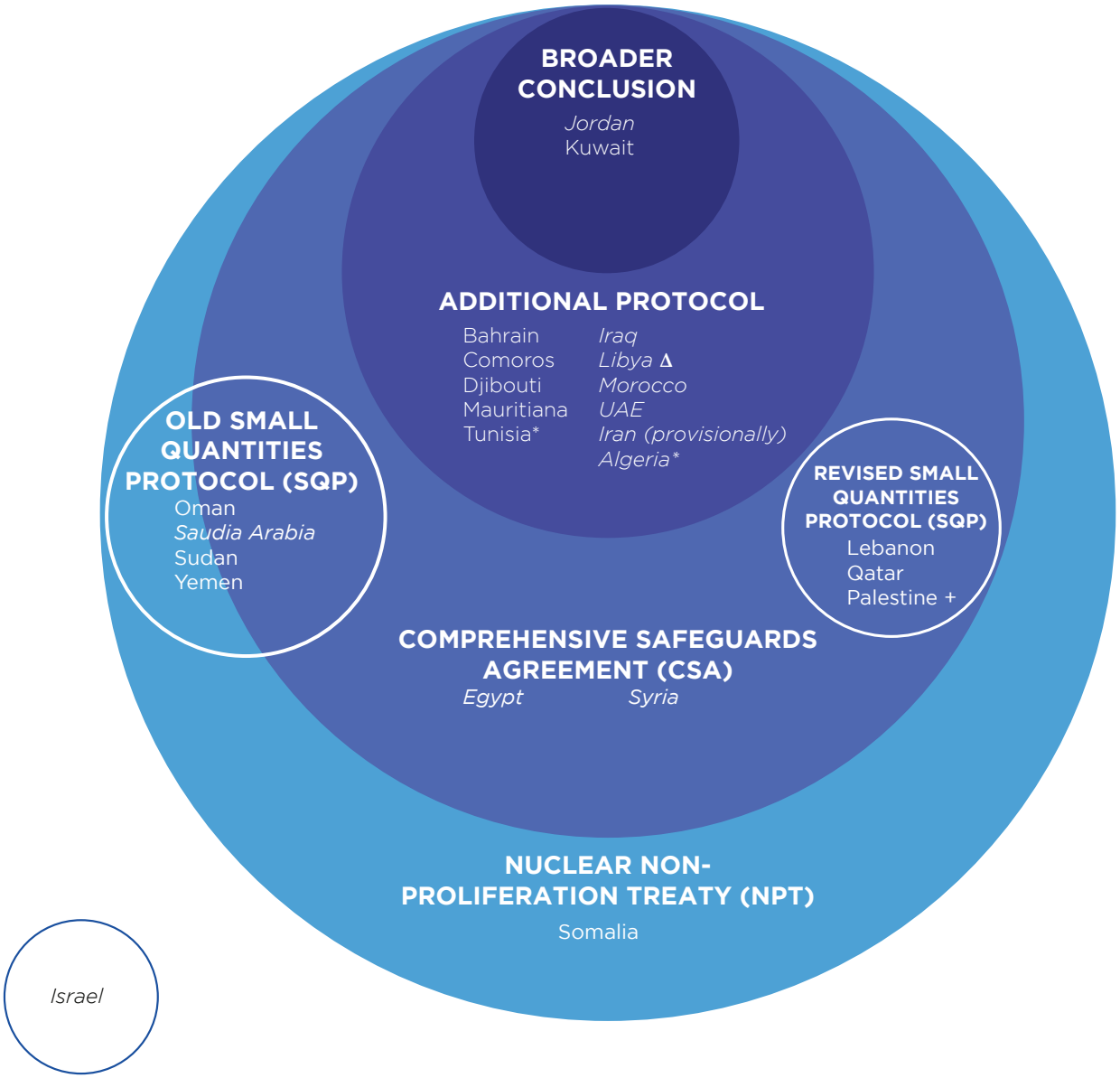
Unless there were a compelling reason otherwise, all the zone parties should have the same level of safeguards obligations. Leaving aside Israel, which is not an NPT party (its accession to the zone is addressed in section 5), under the zone there should be only two variants of safeguards status:

- States with a CSA and an AP in force.

- States with a revised SQP. These states should be a subset of the states with a CSA and an AP in force. That is to say, states with an SQP necessarily have a CSA and should also conclude an AP.

39. In its Safeguards Implementation Report for 2019, the IAEA stated that it is continuing to work with Libya to resolve the Agency's inability to verify information provided by Libya on the actual status of nuclear material at a particular location.

FIGURE 1: Status of adoption of Safeguards Agreements by MENWFZ Prospective Parties (as of January 2021)



Italicised	States with significant nuclear activities
Unitalicised	States without significant nuclear activities
+	CSA signed but not yet in force
*	AP signed but not yet in force
Δ	In 2019 the IAEA reported that it was unable to maintain the broader conclusion for Libya that year

4.5 The safeguards standard

The IAEA has emphasized on many occasions that it is unable to conclude that all nuclear material in a state has remained in peaceful activities unless the state has an AP in force.[40] The conclusion of APs by all states in the Middle East zone is a minimum requirement for the IAEA to ensure the effectiveness of verification in the zone.

As of September 2020, 136 states had APs in force, including 130 states with CSAs, plus the five NPT nuclear-weapon states (NWSs) and India. In other words, 70 per cent of all NNWSs have concluded an AP. More importantly, the percentage of NNWSs with significant nuclear activities that have concluded an AP is even higher – almost 90 per cent.[41] Thus, as a matter of international practice, the combination of the CSA and the AP is firmly established as the contemporary NPT safeguards standard.

States in the Middle East are behind in adopting international practice with regard to APs. Three key states in the prospective Middle East zone (Egypt, Saudi Arabia and the Syrian Arab Republic) have not signed an AP, one (Algeria) has signed but not yet brought its AP into force, and for another (the Islamic Republic of Iran), its implementation of its AP is only provisional. It is important for these states to conclude APs, especially considering that two of these states have been found in non-compliance with their safeguards agreements and one has had serious safeguards failures.

Some states argue that the conclusion of an AP is voluntary; others say they will not conclude a protocol until the NWSs meet their NPT disarmament obligations, or – in Egypt's case – until Israel joins the NPT. However, such a position currently undermines the NPT and the IAEA safeguards regime and will undermine the zone objectives. The relationship is very clear between the NPT, IAEA safeguards and the AP:[42]

- The NPT requires each NNWS to accept IAEA safeguards on *all* its nuclear material.
- The NPT gives the IAEA the responsibility of verifying this.
- The IAEA emphasizes it is unable to provide assurance that safeguards are applied to all the nuclear material in the state – that is, the state has no undeclared nuclear materials and activities – unless an AP is being implemented.
- Thus, performance of a fundamental provision of the NPT is dependent on the state implementing an AP.

40. See, for example, IAEA, "Nuclear Safeguards Conclusions Presented in 2016 Safeguards Implementation Report", 2017, https://www.iaea.org/newscenter/news/nuclear-safeguards-conclusions-presented-in-2016-safeguards-implementation-report.
41. Sixty-three CSA states have significant nuclear activities. Of these, 54 have CSAs in force and one (the Islamic Republic of Iran) is implementing its AP provisionally. Three (Algeria, Belarus and Malaysia) have signed APs but have not yet brought them into force. Five of these states (Argentina, Brazil, Egypt, the Syrian Arab Republic and the Bolivarian Republic of Venezuela) have yet to negotiate an AP. See the IAEA's AP status report, the most recent being dated 18 September 2020, https://www.iaea.org/sites/default/files/20/01/sg-ap-status.pdf.
42. J. Carlson, Is the Additional Protocol 'Optional'?, Trust and Verify, no. 132, 2011, pp. 6–9, https://www.vertic.org/media/assets/TV/TV132.pdf.

Even though the AP has been in existence now for 23 years, there still appear to be misunderstandings in some states in the region about what the IAEA can and cannot do under it. IAEA inspectors are not free to go anywhere any time. APs contain detailed provisions on the locations that inspectors can access and the procedures that apply to such access. In the case of complementary access to resolve a question or inconsistency, the state is to be given an opportunity to clarify and facilitate the resolution of the matter,[43] and the AP specifies the activities that can be undertaken during access.[44] The state can put in place managed access arrangements to protect sensitive information.[45]

To achieve a verifiable and sustainable Middle East NWFZ, all parties must be prepared to conclude and implement an AP. It is suggested that the Middle East zone treaty include a requirement to conclude an AP with the IAEA, as required under the most recent NWFZ treaty, the Treaty of Semipalatinsk.

4.6 Is the AP sufficient?

While the AP is a considerable advance on the CSA alone, the Model Additional Protocol was approved 23 years ago and reflected various compromises. In view of the particular challenges presented by a Middle East zone, the parties may wish to consider improvements to the current AP provisions. Areas for consideration are discussed in the following subsections.

INSPECTOR ACCESS

One major area for improvement is the access rights of inspectors. Inspectors from the European Atomic Energy Community (Euratom), the *supranational* safeguards organization for all European Union (EU) member states, have access at all times to all places and data and to all persons who, by reason of their occupation, deal with materials, equipment or installations subject to Euratom safeguards, to the extent necessary to ensure compliance with such safeguards.[46] The IAEA Statute has a similar provision,[47] but this authority has not been incorporated into CSAs. Reference can be made also to the IAEA expanded mandate under South Africa's disarmament verification, which provided the IAEA inspectors *access any time, any place with a reason*. The effectiveness of verification in the Middle East zone will depend on the level of confidence states in the region want to achieve, which in turn will be affected by the level of access and transparency they are prepared to grant inspectors.

ADDITIONAL MONITORING OF SENSITIVE MANUFACTURING AND IMPORTS

The JCPOA provides for closer monitoring of manufacture of centrifuge components. (However, if enrichment is excluded from the zone, there should be no such

43. IAEA, Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards, INFCIRC/540, article 4.d.
44. IAEA, INFCIRC/540, articles 5.c and 6.d.
45. IAEA, INFCIRC/540, article 7; see also article 15.
46. Euratom Treaty, article 81.
47. IAEA Statute, article XII.A.6.

manufacturing.) Another interesting and potentially important element in the JCPOA is the provision for the Joint Commission to operate a procurement channel to review and decide on proposals to transfer items controlled by the Nuclear Suppliers Group.[48] This mechanism would increase the effectiveness of national export controls on proliferation-sensitive items and materials. More generally, a mechanism similar to the JCPOA's Joint Commission might be considered for the exercise of appropriate functions in the Middle East zone.

One area that might be examined is updating the AP's annexes for the purposes of the zone. For instance, provisions on reporting and monitoring of tritium are notably lacking in the AP as these were blocked in the AP negotiations by a small number of states. Other areas not covered by the AP include high explosive containment vessels and specialized high explosive materials.[49]

ELABORATION OF MEASURES FOR DUAL-USE ACTIVITIES AND ITEMS OF POSSIBLE APPLICATION TO WEAPONIZATION

Under the JCPOA, certain activities that would fall under weaponization activities are prohibited; others can be undertaken for non-nuclear purposes, subject to monitoring, if approved by the JCPOA's Joint Commission. The zone negotiators could consider adopting similar procedures to approve and monitor sensitive dual-use activities. If such procedures are adopted, the zone negotiators may want to specify who will undertake the monitoring of these activities, as that was not addressed in the JCPOA.

ELABORATION OF VERIFICATION PROCEDURES FOR URANIUM PRODUCTION

The zone negotiators could consider adopting a similar provision to those in the JCPOA, which improve information reporting and access to production and processing of uranium ore concentrates.

WIDE-AREA ENVIRONMENTAL SAMPLING

The possible future deployment of wide-area environmental sampling is referred to in the AP.[50] Environmental sampling techniques were used to good effect during verification activities in Iraq the 1990s.[51] In the 1990s, this technology was not considered cost-effective for general use, but this situation could change with advances in technology, for specific or limited use, or where conditions are particularly suitable.

ADDITIONAL AREAS FOR VERIFICATION AND MONITORING

The parties to the zone could agree on additional mandates for IAEA or regional inspectors, as was done under the JCPOA, for example the verification of facility modification or the dismantlement and monitoring of nuclear material quality and quantity limits.

48. See JCPOA, annex IV, section 6.
49. These are covered by the Nuclear Suppliers Group dual-use list; see paras 5.B.7 and 6.C.1.
50. IAEA, INFCIRC/540, article 9.
51. US Congress, Office of Technology Assessment, Environmental Monitoring for Nuclear Safeguards, 1995, https://ota.fas.org/reports/9518.pdf.

Euratom inspector performing in-field verifications

European Commission

4.7 Clarification procedures and challenge inspections

An issue to be considered is how clarification procedures in the case of unresolved safeguards issues would take place in the zone, and who can initiate them. Under IAEA safeguards agreements, all inspections are initiated by the IAEA itself, including *special inspections*. Special inspections cover circumstances where the information provided by the state is not adequate for the IAEA to fulfil its responsibilities,[52] including circumstances where it is necessary to investigate possible undeclared nuclear activities. A state concerned about possible violations in another state can draw the IAEA's attention to its concerns, but it is up to the IAEA whether and how it investigates.

The Treaty of Pelindaba provides for a clarification procedure: if a party considers that another party is in breach of its obligations under the treaty, it may request the latter to provide an explanation. This process could include technical visits agreed on between the parties.[53] If the matter is not resolved, the complainant may bring the complaint to AFCONE, which is to request an explanation from the other party. Depending on the response, AFCONE may request the IAEA to conduct an inspection.

Such a procedure should be considered for the Middle East zone treaty. However, the timescales in the Pelindaba procedure are fairly lengthy (the party complained of has 30 days to respond to the complainant, followed by 45 days to respond to AFCONE, before AFCONE can request an IAEA inspection), and the IAEA is not obliged to undertake an inspection. Middle East zone parties may see a need for a stronger mechanism.

52. IAEA, INFCIRC/153, para. 73.
53. Treaty of Pelindaba, annex IV.

Consideration could be given also to a clarification process that is initiated by a member state, that is, inspections that can be initiated by a party rather than being dependent on the verification agency. The Chemical Weapons Convention (CWC) and the CTBT have mechanisms along this line. The inspectorate body under the CWC, the Organisation for the Prohibition of Chemical Weapons (OPCW), conducts routine inspections at declared sites but does not attempt to detect undeclared activities away from declared sites. A treaty party may request a challenge inspection, a process included in the CWC, if it has reason to believe there may be a prohibited activity. An obvious concern is the possibility of frivolous or vexatious inspection requests. To guard against these, a request for a challenge inspection can be disallowed by a three-quarters majority vote of the OPCW's Executive Council (a process termed a *red light* filter, as the decision by the governing body is needed to stop the request).

The CTBT has no routine inspections and no standing inspectorate. Instead, an IMS is operated under the treaty, looking for indicators of a prohibited event, namely, a nuclear explosion. After the CTBT enters into force, a party believing that a nuclear explosion has taken place may call for an on-site inspection of the location concerned. The request must be approved by at least 30 of the 51 members of the CTBT Organization Executive Council (roughly a 60 per cent majority) – a process termed a *green light* filter, as a decision by the governing body is needed to approve the request.

If zone parties wish to consider a challenge inspection mechanism, the CWC approach with its red light filter would seem an appropriate model. The approach of the CTBT green light filter may be too difficult to achieve in practice: as inspections provide the means of resolving suspicions, it would be counterproductive to set the bar too high.

An alternative to a challenge inspection procedure would be to establish a mechanism with the IAEA (and the regional inspectorate) for the IAEA to undertake an inspection (or complementary access), if requested. The zone parties would need to decide on a red light filter or other mechanism to guard against frivolous or vexatious requests.

4.8 Regional verification arrangements

Regional arrangements for safeguards and related verification, complementing IAEA safeguards, could make a major contribution to ensure compliance, prevent breakout options and enhance confidence-building, benefiting the zone parties and, through sharing the burden of inspections and monitoring, benefiting the IAEA. Further, as the Euratom example shows, a regional organization could make a significant contribution to the development of regional political arrangements.

Currently, two regional safeguards systems could be useful to examine if regional states consider a regional verification system: Euratom and the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC). The establishment of each reflected particular historical and regional circumstances: the Euratom Treaty pre-dated the NPT, and ABACC pre-dated the accessions of Brazil and Argentina to the NPT.

EURATOM

Euratom was established by the 1957 Euratom Treaty (the same year the IAEA was established). Euratom is a supranational safeguards organization, taking the place of the national safeguards authority for all EU member states.

Euratom and IAEA safeguards procedures are very similar, having developed in parallel. The working relationship between Euratom and the IAEA has evolved over almost six decades. Each inspectorate operates under its specific mandate and draws its own independent conclusions. Euratom draws conclusions in respect of individual operators and holders of nuclear material in the EU. The IAEA draws conclusions in respect of each NNWS's compliance with its CSA. A "partnership" approach was adopted, emphasizing strong cooperation between the two inspectorates. Avoiding duplication and ensuring efficiency have been long-running objectives. Where possible, safeguards activities are performed jointly. Verification equipment costs are shared. Inspection tasks are split and verification results are shared to avoid duplication of effort.[54]

Of around 1,200 inspections carried out by Euratom annually, more than half are joint inspections with the IAEA. The difference in numbers between joint inspections and other inspections reflects several factors, including the differences in mandate and scope:

- A key difference between the two systems is the IAEA's emphasis on *timeliness*: timely detection of diversion is a fundamental safeguards objective, and inspection frequencies are set accordingly. Euratom was established in the pre-NPT era, when timeliness was not as critical. Historically, the focus of Euratom was accountability, ensuring nuclear materials are not diverted from their declared use. Under the Euratom Treaty, a member state could withdraw nuclear material from peaceful to military use provided this was declared. It was expected that political processes would then intervene as necessary to deal with the situation. Timeliness became important when the IAEA's safeguards system was developed pursuant to the NPT.

- The IAEA conducts a number of short-notice random inspections and unannounced inspections under CSAs, and complementary access under APs. Where possible, the IAEA offsets this effort with reductions in its presence during regularly planned inspections, instead using the findings of Euratom inspections.[55]

- In the Euratom NWSs (France and the United Kingdom), the IAEA inspects only a small number of designated facilities under the voluntary offer agreement, while Euratom inspects all civilian facilities.

Other significant differences between Euratom and IAEA safeguards include:

- Euratom inspectors have access at all times to all places and data, and to all persons

54. Euratom briefing to the European Parliament, September 2017, https://www.europarl.europa.eu/RegData/etudes/BRIE/2017/608665/EPRS_BRI%282017%29608665_EN.pdf. See also P. Szymanski, The EURATOM Regional Safeguards System, European Commission, 2011, https://www.iaea.org/sites/default/files/euratom211111.pdf.
55. European Commission, Report on the Implementation of Euratom Safeguards in 2014, https://ec.europa.eu/energy/sites/ener/files/documents/20151211%20Annual_Report%202014.pdf (most recent at the time of writing).

who deal with materials, equipment or installations subject to safeguards, to the extent necessary to ensure compliance with safeguards. For the Middle East zone, the parties may wish to grant inspectors this authority, either through additional arrangements with the IAEA or through a regional arrangement.

- Euratom has staff inspecting in their own states, taking the approach that inspectors can be more effective when they are operating in their own language and cultural context. A major factor in this practice is that in most EU member states there is no national safeguards authority; Euratom acts in place of such an authority.

- The IAEA, in contrast, specifically avoids assigning inspectors to their own states because of the risk that they could come under national influence or pressure. Euratom believes such risk is minimized because Euratom is a career service, compared with the IAEA's practice of fixed-term contracts.

- Euratom safeguards apply to all nuclear material from ore to waste. IAEA safeguards measures do not apply to ore and even under APs the safeguards measures for mining, source material and waste are more limited than under Euratom safeguards.

- In Euratom's case, all special fissile materials (corresponding to the IAEA's special fissionable materials, including enriched uranium and plutonium) are owned by Euratom rather than by individual states.[56] Although ownership is not a safeguards measure as such, it reinforces the notion that the materials are not nationally owned. As such, it reframes safeguards and verification from a question of what a state is allowed or not allowed to do with its fissionable materials, as well as reinforcing the rights of Euratom for full information on and access to nuclear material holdings and uses.

The last point highlights that Euratom safeguards operate as part of a broader nuclear research and energy community, which is also responsible for ensuring a reliable supply of nuclear material to member states and for coordinating nuclear energy policies and nuclear security (physical protection) standards. The Euratom community is now subsumed into the EU, and Euratom safeguards are a function of the European Commission. In considering regional safeguards arrangements, Middle East states should be mindful of the potential for regional arrangements to evolve into broader areas of cooperation.

BRAZILIAN-ARGENTINE AGENCY FOR ACCOUNTING AND CONTROL OF NUCLEAR MATERIALS

ABACC is an international organization established under the 1991 Bilateral Agreement between Argentina and Brazil covering the exclusively peaceful use of nuclear energy. At that time there was mistrust between Argentina and Brazil regarding each other's nuclear programmes, but they were not then ready to address these concerns by joining the NPT. The main function of ABACC is to administer and apply the Common System for Accounting and Control of Nuclear Materials to all nuclear material in all nuclear

56. Euratom Treaty, article 86.

activities in Argentina and Brazil to ensure that these materials are not improperly used for purposes not authorized under the Bilateral Agreement.

In March 1994, three years after they established ABACC (and two months after Argentina joined the Latin American NWFZ), Argentina and Brazil, together with ABACC and the IAEA, concluded a CSA, commonly referred to as the Quadripartite Agreement. Neither state was yet a party to the NPT.[57] Nevertheless, under the Quadripartite Agreement, Argentina and Brazil agreed to accept the application of IAEA safeguards covering all nuclear materials in all nuclear activities carried out within their respective territories to ensure that such materials were not used for nuclear weapons or other nuclear explosive devices.

- The ABACC regime can be seen as a system of mutual inspection, which operates jointly with IAEA safeguards:

- ABACC maintains a panel of persons available for inspections, who are nominated by the Argentine and Brazilian national safeguards authorities. These may be national inspectors or industry experts.

Joint inspections are carried out by the IAEA, the relevant national authority and ABACC inspectors, that is, persons drawn from the ABACC panel. Argentine personnel are chosen to inspect in Brazil, and vice versa.

Under the Quadripartite Agreement, ABACC and the IAEA are to work together, according to compatible safeguards criteria issued by both agencies. However, ABACC and the IAEA are required to draw independent conclusions. Unlike the IAEA, ABACC does not have the authority to verify the absence of undeclared nuclear material and activities (completeness) in Argentina or Brazil.

DIFFERENCES BETWEEN EURATOM AND ABACC

A key difference between the two systems is that Euratom is the safeguards authority for all EU member states, so safeguards involve bilateral collaboration between Euratom and the IAEA, while Argentina and Brazil maintain their national safeguards authorities, so safeguards involve four-way collaboration between ABACC, the IAEA and the two national authorities.

Another significant difference is that, as noted above, Euratom has staff inspecting in their own states. ABACC, in line with its mutual inspection approach, ensures that Argentine inspectors inspect in Brazil, and vice versa.

APPLICABILITY TO THE MIDDLE EAST

Euratom and ABACC both have features applicable to the Middle East context, and the zone can borrow relevant features from both. From ABACC the zone negotiators could consider mutual inspections. The Euratom supranational model, in lieu of national safeguards authorities, has advantages (particularly independence from national

57. Argentina joined the NPT in 1995, and Brazil in 1998.

governments) but requires a greater commitment to regional integration than is currently the case in the Middle East. Basing the Middle East zone on the conventional model of national safeguards authorities would help build expertise and promote a safeguards culture at the national level. The ABACC approach of a regional organization interacting both with national authorities and the IAEA may be more complicated to operate than Euratom but seems more suited to the circumstances of the Middle East. In these respects, two points should be considered:

- To the extent practicable, every effort should be made to deploy inspectors in the states of greatest interest to their own, thus maximizing the confidence-building advantages of mutual inspections. In the Middle East, this will be more complicated given the lack of diplomatic relations among many in the region as well as deep mistrust, compared with ABACC where only two states are involved. A balance will be required between deploying inspectors in the states of greatest interest, as just suggested, and equality and the desirability of broadening representation in inspection teams and optimizing national capacity-building, which could require a more varied pattern of deployments.

- The regional inspectorate should follow the Euratom mandate and practice of accessing all places and persons relevant to the inspection mandate.

Clearly, it will be a major undertaking to introduce regional verification arrangements. In addition to developing and negotiating the institutional aspects, it will be necessary to establish a professional inspectorate, something that will take considerable time and training. It is to be hoped that extra-regional bodies such as the EU and the IAEA will be willing to assist.

An additional aspect the parties need to take into account is that the costs of operating a regional inspectorate are likely to be substantial. Activities and equipment can be shared with the IAEA to avoid duplication. Effectively, however, this would amount to greater costs for parties than in existing NWFZs where the IAEA is working alone, and in practice just continuing to implement its work under the CSA and AP in these member states. In considering questions of cost, the parties should take into account that reduction of tensions and confidence-building are national security benefits. In the absence of these benefits, they would be spending more in defence costs, likely without gaining a corresponding security benefit. Viewed this way, verification costs may save defence expenditures in the long term.

Institutional aspects, such as defining the functions and governance of the regional organization, will require detailed consideration. Coordination with other treaty organizations, particularly the IAEA and AFCONE, will be essential.

Compliance issues

A particularly complex area will be decisions on treaty compliance. The IAEA has an independent responsibility to make these decisions with respect to safeguards agreements under the NPT. It would seem preferable for the regional organization to leave this to the IAEA in respect of all matters covered by existing safeguards

The SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East) Centre, is the Middle East's first major international research centre for science applications.

IAEA

agreements; any parallel process could lead to confusion. The regional organization will need to include a decision-making mechanism for determining treaty matters that are outside the scope of safeguards or verification areas not covered by the IAEA, if any.

Importance of multi-skilling and multitasking among inspectorates

While this paper has focused on nuclear verification, it must not be overlooked that regional arrangements might also be developed for other WMD. Every effort should be made to have multidisciplinary inspector teams, so that nuclear inspection teams liaise with chemical weapon and biological weapon specialists to ensure that indicators relevant to the other weapons can be recognized and actioned, as necessary.

4.9 Other confidence-building and transparency measures

Ongoing transparency measures will be important to complement the verification task. In this regard, the verifier is not looking simply at whether a state could conceal a nuclear weapon, which is a relatively small object. The state would also need, among other requirements, delivery systems (missiles or nuclear-capable aircraft); personnel for guarding, maintaining and launching nuclear weapons; and a command and control structure – in other words, a whole range of capabilities and activities that would have to be hidden, and for which there would be indicators or observables. The key to effective verification will be establishing procedures that will detect such indicators. These could include innovative approaches such as societal verification.

While confidence-building and transparency measures are often thought of as voluntary, this is not necessarily the case. The Treaty on Open Skies is one example of such measures being legally binding. Additional confidence-building and transparency measures might include mutual inspections, challenge inspections, and constraints on proliferation-sensitive materials and activities. The JCPOA indicates some of the types of complementary measures that parties to the zone may need to consider.

More generally, verification can be complemented by confidence-building and transparency measures, which can be made legally binding if the parties so decide. Possible examples include:

- Identifying military-related indicators of possible nuclear weapons relevance, establishing detection methods and developing corresponding transparency arrangements. Areas include military doctrines, delivery systems, force structures, training, and command and control systems.

- Transparency arrangements could include liaison officers, Open Skies arrangements, and transparency visits.

- Promoting transparency in national nuclear programmes, including through regional collaboration in research and possibly safety regulation. The International Centre for Synchrotron Light for Experimental Science and Applications in the Middle East (SESAME),[58] though not fuel cycle related, is an outstanding precedent for what can be achieved by regional collaboration.

58. SESAME is an autonomous intergovernmental organization and cooperative venture by scientists and governments of the region based in Jordan. It is a "third-generation" synchrotron light source. For additional information, see https://www.sesame.org.jo/about-us/what-is-sesame.

Pantex workers transport B53 nuclear bomb at the plant

5. ELIMINATION OF NUCLEAR WEAPONS

So far, this paper has mainly discussed verification in support of non-proliferation commitments in the prospective zone. Verification in support of nuclear disarmament raises a different range of issues.[59] To date, the only multilateral experience with the verification of nuclear disarmament is with South Africa, which had dismantled its nuclear weapons without an IAEA presence (for an analysis of the IAEA experience in verifying South African disarmament, see Annex II). The IAEA's task, therefore, was the normal safeguards function of verifying the correctness and completeness of South Africa's declared inventory of nuclear material. This task included confirming dismantlement of the weapon programme, which was essential to drawing conclusions about completeness (the absence of undeclared nuclear material and activities, whether material withheld from the initial inventory declaration or material produced subsequently). Ongoing safeguards were required to ensure early detection should the weapon programme be reconstituted.

The South African experience showed this is likely to take substantial resources and time, best implemented by a dedicated team (including specialists from NWSs), and special arrangements must be established to ensure the protection of proliferation-sensitive information.

Israel is the only state in the proposed zone believed to have nuclear weapons. The point at which verification will apply – whether to the process of dismantlement or only afterwards to the nuclear material resulting from dismantlement – is technical and a secondary question. The fundamental question is a political one: Under what terms would Israel join the zone? Basically, there are two possible approaches:

- Israel joins the zone on the same basis as the other parties, as a NNWS accepting IAEA comprehensive safeguards (the CSA and AP) on all its nuclear material. This is essentially the South African model. However, the IAEA today requires a thorough understanding of a state's past nuclear activities to draw a conclusion on whether the state may have continuing undeclared nuclear activities.

- Israel joins the zone under a phased approach, in which it commits irrevocably to the objective of eliminating all nuclear weapons, and a process is agreed on how and when this will be achieved. At the end of the process, Israel will be a NNWS

59. For background on verification of nuclear disarmament, see for example the work of the International Partnership for Nuclear Disarmament Verification, https://www.ipndv.org; Nuclear Threat Initiative, Innovating Verification: New Tools and New Actors to Reduce Nuclear Risks, 2014, https://www.nti.org/analysis/reports/innovating-verification-new-tools-new-actors-reduce-nuclear-risks. A brief overview is given in J. Carlson, Verifying the Elimination of Nuclear Weapons and Providing Assurance against Breakout, Asia Pacific Leadership Network, 2018, http://www.apln.network/briefings/briefings_view/Policy_Brief_No_57_-_Verifying_the_Elimination_of_Nuclear_Weapons_and_Providing_Assurance_against_Breakout.

under the same conditions as all the other parties.

The first approach would require Israel to first eliminate its nuclear weapons and to place all the recovered nuclear material under safeguards. The obvious problem with this approach is that it is highly unlikely Israel will agree to disarm immediately. Israel will probably require assurance that the zone arrangements are effective before it would irrevocably commit to the zone. In this case, it could be many years before Israel joins the zone. States considering this approach should reflect on whether it is in their interest to have Israel outside the zone for an extended period.

The second approach would require Israel to eliminate nuclear weapons progressively as agreed milestones are achieved. These milestones would be the subject of negotiation and could be directly related to the zone or more broadly related to the regional security situation, could include wider political issues, or could be some combination of these factors. The obvious problem with this approach is that it is requires Israel to agree to full transparency of its nuclear weapon programme.

Whichever way the elimination of nuclear weapons proceeds, the lessons learned from South Africa, to date the only state to have disarmed itself of nuclear weapons, will be important. Also, more work on developing nuclear verification approaches is likely to be relevant, including that of the International Partnership for Nuclear Disarmament Verification. The Partnership is an international initiative to promote further understanding of the challenges involved in the verification of nuclear disarmament and to identify potential solutions to overcome those challenges. Some states from the region are participants in this initiative.[60]

The Pelindaba Treaty assigns verification of the process of dismantling nuclear weapons to the IAEA. While the IAEA Statute allows for states to request the IAEA to "apply safeguards, at the request of the parties, to any bilateral or multilateral arrangement, or at the request of a state, to any of that state's activities in the field of atomic energy",[61] verification of nuclear weapon dismantlement is well outside the IAEA's routine safeguards mandate and expertise. There are studies on how IAEA or other international inspectors could verify a nuclear weapon dismantlement process without compromising classified information, but this is currently outside the IAEA's routine mandate.[62]

ILLUSTRATIVE FRAMEWORK FOR A PHASED APPROACH

An illustrative framework for the verification aspects of a phased approach is set out as follows. Since this is specific to just one party to the zone, it is suggested that the details could be specified in a separate agreement, complementary to the zone treaty. The zone treaty would set out the primary commitment: the total elimination of nuclear weapons in accordance with the agreed process.

60. Jordan, Turkey and the United Arab Emirates are participants in the Partnership.
61. IAEA Statute, article III.A.5.
62. J. Carlson, Verification of DPRK Nuclear Disarmament: The Pros and Cons of Non-Nuclear-Weapon States Participating in this Verification Program, Nautilus Institute, 2019, https://nautilus.org/napsnet/napsnet-special-reports/verification-of-dprk-nuclear-disarmament-the-pros-and-cons-of-non-nuclear-weapon-states-specifically-the-rok-participating-in-this-verification-program.

Phase 1:

1. Israel will separate its nuclear programme into two parts: one civilian, to be placed under IAEA safeguards, and the other military, to be transitioned into the civilian programme or eliminated in accordance with the process agreed for this purpose.

   The military programme should comprise only nuclear material ("black-boxed"; see Phase 2, point 2); no nuclear activities would take place in this part other than those involved in dismantling nuclear weapons and preparing nuclear material for transfer to safeguards.

2. Israel would cease production of fissile material and accept IAEA safeguards on all enrichment and reprocessing facilities to verify that production has ceased. If the zone treaty has a general prohibition on enrichment and reprocessing, this would also apply to Israel. If the zone treaty permits low enrichment, Israel could continue this under the same conditions as the other parties.

3. Israel would cease any tritium production and accept IAEA monitoring on relevant facilities to verify that production has ceased.

4. Israel would conclude a safeguards agreement and modified AP accepting IAEA safeguards on all non-military nuclear materials and activities and would declare these to the IAEA. The agreement would also cover the verification activities necessary to implement the process outlined in this framework.

5. The safeguards agreement and AP would provide the IAEA with the necessary legal mandate and technical tools to conduct activities for the detection of any *undeclared* nuclear materials and activities. In this context, *undeclared* has a specific meaning – namely, nuclear materials and activities that Israel is required to declare and submit to verification at a particular point in the disarmament process. It is recognized that while the disarmament process continues, Israel will continue to have nuclear materials (but not nuclear activities) in the military black box (see Phase 2) that are not subject to verification; the IAEA would not seek to locate or access those materials.

Phase 2:

1. Israel would commence a declaration process with the IAEA to establish historic nuclear material production and material flows to enable the IAEA to assess and progressively verify Israel's nuclear material inventory.

2. Nuclear material remaining in military use would be in a black box (not verified), but the IAEA would need to know the overall material categories and quantities of nuclear materials within the black box.

3. Israel would preserve nuclear accountancy records, facility operating records, items relevant to nuclear archaeology, and so on, to support the IAEA's verification activities.

4. Israel would declare laboratories and other facilities that have been involved with processing nuclear material.

5. Israel would decommission and verifiably dismantle all enrichment and reprocessing facilities and all other military-related nuclear facilities within an agreed time frame.

Phase 3:

1. Israel would progressively dismantle nuclear weapons and transfer the recovered nuclear materials irreversibly to safeguards.

2. Agreement would be required on whether the IAEA or other verifiers (such as specialists from among the five NPT NWSs) would oversee the dismantlement of weapons (for example, dismantlement by Israeli personnel under *continuity of knowledge* monitoring arrangements) or whether dismantlement would be left to Israel provided that the corresponding quantities of nuclear material are transferred to safeguards.

3. The "black box" of nuclear material outside safeguards would progressively shrink in accordance with the dismantlement process.

Phase 4:

1. Israel would have no nuclear materials outside safeguards and would declare its non-nuclear-weapon-state status (joining the NPT as a NNWS). Israel would conclude a CSA and a full AP with the IAEA.

Many states in the region might that prefer Israel joined immediately as a NNWS. It is also unclear what Israel's position about joining the zone would be. Would it prefer to follow the South Africa model and disarm prior to joining the treaty as a NNWS, or through a phased approach? While each of these options has advantages and disadvantages, regional states may conclude they would have to compromise and adopt a practical approach if the alternative is having no zone, or a zone without Israel's participation. Even if it is only possible to extend the treaty commitments to Israel progressively, it would nonetheless be a great achievement.

A treaty that is part of a larger regional process of substantially reducing tensions in the zone, that removes the motivation to proliferate, and that mitigates the risk of a virtual arms race (or worse) is well worth having. A treaty that can achieve this outcome between key parties such as Egypt, the Islamic Republic of Iran, Saudi Arabia, the Syrian Arab Republic and possibly Turkey would be of enormous benefit to those states, and to the region as a whole, even if Israel will join in a later stage or progressively.

6. ENTRY INTO FORCE

The EIF formula for the Middle East zone treaty will be closely related to how Israel is included in the zone. Broadly speaking, there are four options:

1. The treaty does not enter into force until all states in the zone ratify.

2. The treaty does not enter into force until all specified states ratify. For example, the treaty could specify the states that have significant nuclear activities.

3. The treaty does not enter into force until ratified by a specified number of parties. For example, the Treaty of Pelindaba required 28 ratifications, just over half the states in the African zone.

4. The treaty enters into force for each party as it ratifies (that is, there is no minimum number of ratifications).

If option 1 is chosen, and Israel can join the zone treaty only as an NNWS, then the treaty might not enter into force for many years, possibly never. Even without the issue of Israel's status, a requirement for all states to ratify puts the treaty at the mercy of the slowest or most reluctant state in the zone.

If option 2 is chosen, the effect of Israel depends on whether Israel is included in the required ratifications. Assuming it is, then if Israel can join only as an NNWS, the situation is similar to option 1, and the treaty might not enter into force for years.

Under options 3 and 4, EIF would not be dependent on any one specific state.

Another option related to the EIF formula is that the treaty could provide for provisional application in advance of EIF. For example, if option 1 or option 2 were followed, and Israel could join only as an NNWS, then aspects of the treaty could be brought into provisional operation, including with respect to Israel (assuming Israel could validly sign before meeting the qualifications for a party, and was prepared to sign). The treaty would fully enter into force when Israel qualified as a party (and assuming all other required ratifications had been received). This idea has some similarity with the circumstances of the CTBT: while ratifications required for EIF are still outstanding, key parts of the treaty are in provisional operation. However, the CTBT has a high bar EIF formula, and after 24 years, the treaty's EIF is still uncertain. Such a prolonged EIF period (with or without the option for provisional operation) would limit the level of confidence that the Middle East treaty could provide.

Regional states will have to weigh the various EIF options (the phased approach, as well as provisional operation) as ways to include Israel in the process if it does not join at the outset as an NNWS. In such a case, it may be preferable to allow Israel to

meet the requirements of the treaty from within the treaty (that is, through a phased dismantlement process, lower bar of EIF and provisional application) rather than delay the treaty's EIF for an extended period or weaken its effectiveness through a lengthy and uncertain period of "provisional" status.

7. CONCLUSIONS

A Middle East NWFZ can play a vital role, as part of a regional process, in reducing tensions and therefore reducing the motivation to proliferate, but only if all parties are fully confident that commitments within the zone are being honoured. This requires verification arrangements that are both rigorous and credible.

The need for the highest standard of verification is demonstrated by four of the six reported cases of safeguards non-compliance having occurred within the proposed zone. These cases prompted the strengthening of the IAEA's safeguards system, especially the development of the Model Additional Protocol. Not to apply all available safeguards measures – those contained in APs and further measures addressing the unique risks present in the region – would be to ignore the lessons of the non-compliance cases.

Credibility requires, inter alia, that the key parties as well as the international community have a high degree of confidence in how verification is implemented in practice. This requires the international community to have a sufficient level of transparency and engagement in safeguards implementation. This in turn requires a collaborative relationship with the IAEA and points towards establishing a regional verification system, including mutual inspections. If a regional verification system is established, it is essential for it to be given the resources needed to operate effectively.

Verification will need to be complemented by a range of confidence-building and transparency measures. These include measures to address the challenge of nuclear latency, which was a major focus of the JCPOA. Latency can have a profound impact on verification objectives by dramatically reducing breakout time and undermining the ability to provide timely warning of breakout.

By showing that the verification issues underpinning a Middle East NWFZ can be resolved technically, the expert community can make a major contribution to the resolution of the political issues. This paper has pointed to some of the areas where further work can deliver invaluable outcomes.

While negotiations are progressed, there are practical steps the parties can take in preparation for the commencement of the zone, in particular concluding APs and engaging proactively with the IAEA. Most importantly, it is essential that no party takes actions that will impact adversely on the prospects of the zone. For example, to enable negotiations to proceed in a constructive atmosphere, states should refrain from technical developments that other parties could consider threatening, such as the expansion of enrichment capability or strategic capabilities such as nuclear-capable delivery systems. In this regard, it would be extremely helpful for the Middle East states to revive discussions on regional security structures.

An analytical chemist at the IAEA Nuclear Material Laboratory, analyses material collected by safeguards inspectors.

Dean Calma / IAEA

Finally, the Euratom experience shows that a regional approach to a technical mission, in this case verification, can both enhance national security and contribute to broader political and economic cooperation and development in the region.

ANNEX I:
THE CHALLENGE OF NUCLEAR LATENCY

Nuclear latency refers to the situation where a state has established, under an ostensibly peaceful nuclear programme, dual-use capabilities that *could* be used for the production of nuclear weapons, if the state so decided. The NPT allows states to develop dual-use sensitive technologies such as enrichment and reprocessing, even though this could enable them to get very close to developing nuclear weapons capabilities, provided that the development of such technologies is undertaken in conformity with the treaty.

In the regional context, where a number of states are planning to develop nuclear energy programmes with enrichment capabilities, this could result in several states having latent capabilities. In fact, the underlying objective of the JCPOA was to address this concern with respect to the Islamic Republic of Iran and ensure that the time needed to produce a nuclear weapon, if it sought to do so, would be at least one year, by limiting Iran's enrichment capacity and stocks of enriched uranium (and limiting its reprocessing capability). A weakness in the JCPOA was that most of the limits were temporary. But the hope at the time was that the JCPOA would prepare the way for further negotiations (although a further weakness was that during the JCPOA negotiations, no commitment to further negotiations had been secured).

Regardless of the merits of the JCPOA, the principle is clear. Nuclear latency has major implications for the ability of verification to provide timely warning of misuse of nuclear material and facilities, and these implications must be taken seriously and addressed. A NWFZ proposal that fails to deal with the challenge of latency will not succeed in providing the peaceful use assurances that the parties need.

Latency does not depend on scale, but scale is a major issue. Even small-scale R&D activities can present a proliferation risk. For example, in the case of uranium enrichment, the capacity required to produce sufficient HEU for one nuclear weapon in one year, starting with natural uranium, is around 5,000 SWU.[63] This is essentially the limit applied to the Islamic Republic of Iran's enrichment capacity for 10 years by the JCPOA. The *breakout time* – the time needed to produce sufficient HEU for a nuclear weapon if the Islamic Republic of Iran chose to do so – would be one year, which should be adequate time for detection and international intervention, provided enrichment activities are closely monitored.

Latency becomes a far greater issue if an enrichment programme is commercial scale. Even a modest industrial capacity can provide substantial weapon capability and a very short breakout time. To illustrate, the enrichment capacity required to produce sufficient LEU for the annual fuel requirement of just one typical light water reactor is around 110,000 SWU. The Islamic Republic of Iran has indicated plans to install capacity

63. A SWU is a *separative work unit*, a metric of enrichment effort.

of at least 1 million SWU.[64] From an industry perspective this is modest, sufficient for the annual fuel for around nine reactors. But in nuclear weapon potential, it is massive – in theory sufficient to produce HEU for 200 weapons in a year, or one weapon in two days. In other words, the possible breakout time would be dramatically shortened, from one year to a matter of days.

In reality, the situation is more complicated. To produce HEU enriched to weapons grade, say 90 per cent U-235, centrifuge cascades would need to be reconfigured to produce HEU efficiently. This would take time and should be detected by IAEA safeguards if the facility is declared and under safeguards. Nonetheless, the warning time could be fairly short in the case of a large facility.

There are alternative breakout scenarios, presenting different detection challenges:

- A state that is manufacturing as well as operating centrifuges could build a second, clandestine, enrichment plant and divert LEU from the declared plant for feedstock. The disadvantage for the state is that the diversion should be detected relatively quickly. The possible attraction for the state is speed; it may be able to produce substantial quantities of HEU before the clandestine plant can be found and effective intervention is possible.

- The state could conduct an entire enrichment programme clandestinely, without depending on the diversion of declared nuclear material. The attraction for the state is the lower risk of detection; the disadvantage is that it could take longer than the other scenarios and requires greater replication of facilities. Also, the risk of detection could increase with time. While this scenario does not require a declared enrichment programme, a declared programme could provide cover for activities such as centrifuge development and manufacture.

Any state in the region that can manufacture and operate centrifuges and that proceeds with an R&D programme in uranium enrichment, let alone a commercial-scale enrichment programme, will add to tensions in the Middle East and put substantial strains on the proposed zone. Other states may doubt any claimed energy rationale when the activities do not match the energy programme needs and will suspect the real purpose of such a programme is to provide a nuclear weapon option. This will motivate others to develop the same capability. For example, in the region, the Islamic Republic of Iran manufactures and operates centrifuges and has stated its intention to proceed with a commercial-scale enrichment programme. Saudi Arabia is exploring enrichment capabilities and has stated that if the Islamic Republic of Iran develops nuclear weapons, it will do likewise.[65] If a number of states decided to pursue these capabilities, there is the risk of virtual arms race, undermining regional trust and further destabilizing the region and the wider non-proliferation regime.

64. AEOI's goal is to reach 1mn-SWU in enrichment, MEHR News Agency, 8 April 2020, https://en.mehrnews.com/news/157412/AEOI-s-goal-is-to-reach-1mn-SWU-in-enrichment-spox.
65. R. El Gamal and A. Cornwell, Saudi Arabia Flags Plan to Enrich Uranium as U.S. Seeks Nuclear Pact, Reuters, 9 September 2019, https://www.reuters.com/article/us-energy-wec-saudi-nuclearpower/saudi-arabia-wants-to-enrich-uranium-for-nuclear-power-minister-idUSKCN1VU168.

ANNEX II:

PAST VERIFICATION CASES, OTHER PRECEDENTS AND LESSONS LEARNED

Several verification cases and precedents could be used to help guide the development of nuclear verification for the Middle East zone. These include:

- Safeguards non-compliance cases and other major safeguards breaches
- The JCPOA
- Experience in South Africa verifying that a nuclear weapon programme had been terminated
- Regional safeguards systems, namely Euratom and ABACC

A. Safeguards non-compliance and other major breaches

Six states – four in the prospective Middle East zone – have been reported to the UNSC by the IAEA for being in non-compliance with their safeguards agreements (chronologically, Iraq, Romania, the Democratic People's Republic of Korea, Libya, the Islamic Republic of Iran and the Syrian Arab Republic). Major safeguards breaches have been found in another two states (chronologically, the Republic of Korea and Egypt).[66] These cases illustrate safeguards challenges and vulnerabilities and how the safeguards system has evolved to try to address them.[67] The cases underscore why strengthened safeguards and additional measures would be necessary to ensure compliance with the Middle East zone obligations and to meet the national security needs of all parties to the zone.

IRAQ (REPORTED TO THE UNSC IN 1991)

Iraq was the first NPT party found to be in non-compliance with its CSA. The discovery of Iraq's secret nuclear weapon programme was made after the end of the First Gulf War. In 1991, the UNSC adopted a ceasefire resolution, UNSCR 687 (3 April 1991), in which it requested the IAEA to map out and destroy Iraq's nuclear weapon programme. The UNSC gave the IAEA extensive access rights throughout Iraq, beyond those available to

66. On safeguards non-compliance, see T. Findlay, Proliferation Alert! The IAEA and Non-Compliance Reporting, Belfer Center, Harvard Kennedy School, 2015, https://www.belfercenter.org/publication/proliferation-alert-iaea-and-non-compliance-reporting; J. Carlson, NPT Safeguards Agreements – Defining Noncompliance, Arms Control Today, May 2009, www.armscontrol.org/act/2009_5/Carlson.
67. For a more detailed discussion of these issues, see O. Heininen, IAEA Mechanisms to Ensure Compliance with NPT Safeguards, UNIDIR, 2020, https://unidir.org/publication/iaea-mechanisms-ensure-compliance-npt-safeguards.

the Agency, to investigate Iraq's nuclear capabilities.[68] In the course of its investigations, the IAEA found that Iraq had undeclared nuclear materials and activities, including the development of uranium enrichment technologies, reprocessing experiments, and the development of a nuclear weapon design.

Major elements of Iraq's secret programme were located separate from declared nuclear sites, with no obvious links to these, so the safeguards measures the IAEA was using at the time under the CSA were unlikely to have found them. But other undeclared activities had been undertaken at declared sites in adjacent buildings, which inspectors could not enter because at that time routine inspections at nuclear facilities were limited to *strategic points*.[69]

Between April 1991 and October 1997, the IAEA Action Team, a dedicated team established outside the IAEA's Department of Safeguards to carry out UNSCR 687, completed a series of 30 inspection campaigns, oversaw the destruction and disablement of nuclear facilities, and removed all weapons-usable nuclear materials from Iraq. The campaign to dismantle Iraq's nuclear weapon programme was completed by 1994. The IAEA continued to monitor Iraq's nuclear activities until late 1998, when its inspectors were withdrawn in the face of an impending military strike. The IAEA was unable to return for four years. In 2003, the IAEA reported that there was no evidence of any revival of Iraq's nuclear weapon programme. Saddam Hussein was removed from power in 2003 as part of the US military campaign. The post-Saddam Hussein government has taken several noteworthy steps to demonstrate its support for the non-proliferation regime, including by concluding an AP with the IAEA and ratifying the CTBT.

The discovery of Iraq's secret nuclear programme in the early 1990s was an eye-opening experience for the IAEA and its member states. However, there were some positive aspects of that discovery, especially in the adoption of new safeguards measures and technologies. The existence of clandestine enrichment was first revealed through detection and analysis of microscopic uranium particles on the clothing of hostages who had been held by the Iraqis. Thus, an important new verification tool – environmental sampling – was introduced to safeguards. In unravelling Iraq's nuclear programme, extensive use was also made of satellite imagery. Environmental analysis and satellite imagery have since become established IAEA safeguards tools.

An additional important aspect of the IAEA's verification work in Iraq was the establishment of a specialist inspection team that could be deployed when necessary to protect proliferation-sensitive information. This team comprised inspectors who were nationals of NWSs with the security clearances required to handle nuclear weapons-related technology and information. This approach was also used in the cases of the Islamic Republic of Iran, Libya and South Africa.

As noted earlier, the discovery of Iraq's secret nuclear programme led to an extensive

68. Through UNSC Resolution 687 and subsequent resolutions.
69. *Strategic points* are locations on a nuclear site where under normal conditions information necessary and sufficient for the implementation of safeguards measures can be obtained and verified.

programme to strengthen IAEA safeguards, which has been ongoing since the early 1990s. In 1997, the Board adopted the text of the Model Additional Protocol, one of the major outcomes of the safeguards strengthening effort.

ROMANIA (REPORTED TO THE UNSC IN 1992)

Romania was an unusual case, in that the newly established Romanian government asked the IAEA to investigate suspicious activities carried out by the former regime. The IAEA conducted its inspection in May 1992 and found that undeclared reprocessing experiments had been conducted using small quantities of nuclear material that had been exempted from safeguards. Romania had used exempted material for undeclared plutonium separation experiments in a hot cell. The experiments appeared to have been part of a study into the possible development of nuclear weapons. The IAEA reported Romania's non-compliance to the UNSC for information purposes only, as the issue had been raised by the state itself and had been resolved, and the IAEA Board was satisfied that corrective action had been taken. As a consequence of this case, the IAEA tightened its procedures for the granting of safeguards exemptions and expanded its inspection procedures to include environmental sampling at hot cells.

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (REPORTED TO THE UNSC IN 1993)

The Democratic People's Republic of Korea joined the NPT in 1985 but did not conclude the required CSA until 1992. When the IAEA commenced inspections under the CSA, it soon found discrepancies in the declarations of the Democratic People's Republic of Korea. Analysis of plutonium placed under safeguards showed that its irradiation history was inconsistent with the declaration of the Democratic People's Republic of Korea, indicating that more plutonium had been produced than declared. Using satellite imagery provided by US intelligence, inspectors identified two locations believed to store nuclear waste, access to which could reveal more information about reprocessing activities in the Democratic People's Republic of Korea. The Democratic People's Republic of Korea refused the IAEA's request to conduct special inspections at these locations. After efforts to obtain the state's cooperation failed, in 1993 the IAEA determined that the Democratic People's Republic of Korea was in non-compliance with its safeguards agreement and reported the matter to the UNSC.

This was the first attempt by the IAEA to exercise its right to carry out a special inspection at an undeclared location. As already noted, the IAEA's Board had formally reaffirmed the IAEA's right, in the context of CSAs, to carry out special inspections at undeclared locations. The rejection by the Democratic People's Republic of Korea of the special inspection request highlighted the need for international cooperation in dealing with safeguards violations; the IAEA is not an enforcement agency and depends on state cooperation and, in its absence, support from the UNSC.

The Democratic People's Republic of Korea case also demonstrated the effectiveness of new analytical techniques. The IAEA detected a mismatch between the plutonium that the Democratic People's Republic of Korea presented to it and the declared history of this material. The IAEA was able to conclude that the Democratic People's Republic

of Korea had understated the amount of plutonium it had separated.

This case also demonstrated the importance of states sharing intelligence information with the IAEA. Since then, the use of intelligence information provided by IAEA member states has become an established safeguards practice. The IAEA has also developed substantial capabilities of its own in the collection and analysis of open-source information, including commercially available satellite imagery.

Unfortunately, this case proved too politically difficult to resolve. The Democratic People's Republic of Korea has since become the only state violating safeguards and the NPT that has succeeded in producing nuclear weapons.[70]

LIBYA (REPORTED TO THE UNSC IN 2004)

In 2003, Libya opened secret contacts with the United States and the United Kingdom with the stated intention of eliminating its nuclear and chemical weapons programmes. As part of its secret nuclear programme, Libya had obtained uranium enrichment materials, equipment and components, and nuclear weapon designs, and had ordered the supply of a modular uranium enrichment plant from black market sources.

The United States and the United Kingdom insisted that the programme be irreversibly and verifiably dismantled. Libya insisted that the IAEA, as an international organization, also play a role in verifying and certifying its disarmament. Consequently, at the end of 2003, Libya made a public announcement of its decision to disarm and informed the IAEA about its undeclared activities so the IAEA could verify Libya's return to safeguards compliance. Libya signed an AP and implemented it provisionally pending its EIF.

In the first phase of the verification and dismantlement process, US and UK teams removed the most sensitive items. Subsequently, the IAEA undertook a series of inspections to verify that all remaining nuclear material and activities had been declared by Libya and the material placed under safeguards. Dismantlement operations were carried out by the United States and the United Kingdom rather than by the IAEA itself. In 2004, the IAEA reported that Libya was actively cooperating in the verification and dismantling effort. Libya's non-compliance was reported to the UNSC for information purposes only, as had been done with Romania.

The Libyan case was a further illustration that traditional safeguards, which focused primarily on declared facilities and locations, had major limitations when it came to the detection of undeclared nuclear activities. There were several sites of which the IAEA was completely unaware until the Libyans informed the Agency about them. The IAEA continues to face major challenges in detecting undeclared nuclear activities in states without an AP, and even where an AP is in force, the AP is not sufficient in itself to enable the IAEA to draw a conclusion on the absence of undeclared nuclear material

70. The Democratic People's Republic of Korea announced its withdrawal from the NPT in 2003. The validity of this withdrawal has not been definitively determined. The IAEA sought guidance from NPT parties on the legal status of the withdrawal, but such guidance has not been forthcoming. See IAEA, Application of Safeguards in the Democratic People's Republic of Korea, GOV/2011/53-GC(55)/24, 2011, https://www.iaea.org/sites/default/files/gc/gc55-24_en.pdf.

and activities. Equally important in developing strengthened safeguards are the IAEA's information collection and analysis activities. An AP provides the opportunity to access more information and to investigate questions and apparent inconsistencies in a non-confrontational way, but availability of broader information and expert information analysis are needed to ensure APs are implemented to best effect.

In 2008, the IAEA reached a broader conclusion that all the nuclear material in Libya remained in peaceful activities. However, in 2020, the Agency reported that it had been unable in 2019 to verify certain material and was therefore unable to maintain this conclusion.[71]

ISLAMIC REPUBLIC OF IRAN (REPORTED TO THE UNSC IN 2006)

The history of the Islamic Republic of Iran case is particularly complex, and the IAEA's efforts to resolve the case remain ongoing. The following is only a very brief outline, focusing on the aspects most relevant to the Middle East zone.

During the 1990s, there were indications of possible undeclared nuclear materials and activities in the Islamic Republic of Iran, but the IAEA did not have location-specific information on which it could act. In particular, there was information suggesting the supply of uranium hexafluoride (the feedstock for uranium enrichment) from China to the Islamic Republic of Iran, but neither China nor the Islamic Republic of Iran would confirm this, despite IAEA inquiries. Eventually, in 2002, an Iranian dissident group revealed that the Islamic Republic of Iran was building an underground enrichment plant at Natanz. This gave the IAEA the opportunity to begin on-site investigations. Despite Iranian efforts at concealment and obstruction, inspectors succeeded in uncovering some 20 years of undeclared research, development, testing and manufacture of equipment and facilities to produce enriched uranium and to separate plutonium – activities claimed to be for peaceful purposes but also of a kind required for a nuclear weapon programme. These activities were not reported to the IAEA, a major violation of the Islamic Republic of Iran's safeguards obligations.

In 2003, a number of IAEA Board members expressed the view that the Islamic Republic of Iran was in non-compliance with its safeguards agreement and should be reported to the UNSC. Other Board members, however, argued for a delay in a non-compliance decision to facilitate efforts to reach a negotiated outcome. The Islamic Republic of Iran agreed to suspend enrichment and other activities while negotiations were pursued with France, Germany and the United Kingdom. Little progress was made, and in 2005, the Islamic Republic of Iran resumed the suspended activities. This led to the IAEA reporting the Iran to the UNSC for non-compliance in 2006. The UNSC adopted a resolution demanding that the Islamic Republic of Iran re-suspend enrichment, reprocessing and heavy water activities and cooperate fully in resolving the IAEA's concerns. The UNSC also imposed sanctions on Iran.

In 2007, the IAEA and the Islamic Republic of Iran negotiated a workplan to resolve key

71. The IAEA provided no further information on the circumstances.

issues. Although the Iranian cooperation was far from satisfactory,[72] the IAEA was able to conduct a substantial programme of inspections and gathered an increasing range of information on the extent of Iran nuclear activities. Evidence emerged of apparent weaponization activities, and in 2008, the IAEA began reporting on what it called "possible military dimensions" in the Islamic Republic of Iran's nuclear programme. The IAEA's efforts to clarify these matters led to a detailed report on possible military dimensions in November 2011. The UNSC reaffirmed the Islamic Republic of Iran's obligation to cooperate fully with the IAEA in resolving these matters.

In 2013, the Islamic Republic of Iran and the IAEA agreed on a framework for cooperation for resolving outstanding matters, principally relating to possible military dimensions. However, progress remained difficult, with the Islamic Republic of Iran denying access to a number of sites.[73]

In 2015, after two years of negotiation, the JCPOA was concluded between the Islamic Republic of Iran and the EU, China, France, Germany, the Russian Federation, the United Kingdom and the United States. An important aspect of the JCPOA was the undertaking by the Islamic Republic of Iran to return to implementing its AP, which it had suspended for some ten years. The Islamic Republic of Iran undertook to apply the protocol provisionally and to seek its ratification after eight years. (The JCPOA is further discussed in section B of this annex.)

Following the election of President Trump in 2016, the JCPOA came under increasing attack by the United States. In 2018, the United States repudiated the JCPOA and reimposed national sanctions on the Islamic Republic of Iran. The other participants have attempted to maintain the JCPOA.

At the time of writing (September 2020), the Islamic Republic of Iran has been exceeding some of the limits set out in the JCPOA as a means of pressuring the other participants to do more to provide relief from US sanctions and its "maximum pressure" campaign. Meanwhile, the IAEA continues to express concern that the Islamic Republic of Iran is not cooperating sufficiently in the resolution of historic issues of possible military dimensions.[74] The JCPOA is under enormous strain, and it is unclear if it is possible to preserve it. The need for serious negotiations for a long-term resolution remains as strong as ever, as does the need for all sides to build confidence and trust.

SYRIAN ARAB REPUBLIC (REPORTED TO THE UNSC IN 2011)

In September 2007, Israeli aircraft destroyed a building at a site known as Al-Kibar (also called Dair Alzour) in the northeast of the Syrian Arab Republic. After the airstrike,

72. IAEA, 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, 2007, https://www.iaea.org/sites/default/files/gov2007-58.pdf.
73. IAEA, Final Assessment on Past and Present Outstanding Issues regarding Iran's Nuclear Programme, GOV/2015/68, 2015, https://www.iaea.org/sites/default/files/gov-2015-68.pdf.
74. IAEA Director General's Introductory Statement to the Board of Governors, 9 March 2020, https://www.iaea.org/newscenter/statements/iaea-director-generals-introductory-statement-to-the-board-of-governors-9-march-2020; F. Murphy, IAEA Voices Serious Concern at Iran's Stonewalling on Old Sites, Reuters, 5 June 2020, https://www.reuters.com/article/us-iran-nuclear-iaea/iaea-voices-serious-concern-at-irans-stonewalling-on-old-sites-idUSKBN23C2CH.

the Syrian Arab Republic undertook large-scale clearing and levelling operations at the site, which removed or obscured the remains of the destroyed building. This was followed by construction of a new building covering the location of the previous building. Several months later, in April 2008, US intelligence released photos reportedly taken at the site before the airstrike.[75] These showed a building closely resembling the Democratic People's Republic of Korea's 25 megawatt graphite-moderated reactor, suggesting that the building had been a nuclear reactor developed with assistance from the Democratic People's Republic of Korea. The Syrian Arab Republic maintained that the destroyed building was a non-nuclear military installation and that it had had no nuclear-related cooperation with the Democratic People's Republic of Korea.

The IAEA sought to investigate whether there had been a reactor at Al-Kibar, and the Syrian Arab Republic provided access to the site in June 2008. Despite Syrian efforts to destroy evidence of its activities at the site, and its denial of access to the debris removed from the site, inspectors found a significant number of particles of uranium, graphite and stainless steel – all consistent with information indicating there had been a natural uranium-fuelled, gas-cooled, graphite-moderated reactor at the site. Inspectors also found remnants of a river water pumping system consistent with the cooling system for this type of reactor. In 2011, the IAEA concluded that the destroyed building was very likely a reactor and should have been declared under the Syrian Arab Republic's safeguards agreement.[76] The IAEA Board determined that the Syrian Arab Republic was in non-compliance with its safeguards agreement. The Syrian Arab Republic's lack of cooperation with inspectors was a major factor in the Board's decision.

The IAEA also found indications of undeclared nuclear material at another Syrian site and has unsuccessfully sought access to that and other sites. The IAEA has called on the Syrian Arab Republic to conclude an AP to facilitate the Agency's verification activities, but the Syrian Arab Republic has not done so. Further on-site investigations in the Syrian Arab Republic have not been possible owing to the civil war.

REPUBLIC OF KOREA (CONSIDERED BY THE IAEA BOARD IN 2004)

The Republic of Korea case arose when environmental sampling by IAEA inspectors revealed indications of undeclared uranium enrichment and plutonium separation experiments. The Republic of Korea was about to bring its AP into force at that time, and a full investigation was delayed until this happened, in 2004. Korean authorities then reported they found scientists had carried out unauthorized small-scale uranium enrichment experiments in 2000. The IAEA suspected prior to the Republic of Korea's announcement that it had not reported all activities, and in fact the Republic of Korea had refused requests by the Agency to visit the suspected installation, refused to acknowledge in 1999 that it had conducted plutonium separation experiments, and in August 2004 did not report all past conversion activities.[77]

75. D.E. Sanger, Bush Administration Releases Images to Bolster Its Claims about Syrian Reactor, New York Times, 25 April 2008, https://www.nytimes.com/2008/04/25/world/middleeast/25korea.html.
76. IAEA, Implementation of the NPT Safeguards Agreement in the Syrian Arab Republic, GOV/2011/30, 2011, https://www.iaea.org/sites/default/files/gov2011-30.pdf.
77. P. Goldschmidt, "Exposing nuclear non-compliance," Survival, vol. 51, no. 1, 2009, p. 152; T. Findlay, Proliferation Alert! The IAEA and Non-Compliance Reporting, p. 74.

The IAEA sent inspection teams to investigate and found that other undeclared experiments had taken place at various times over an extended period from 1979 to 2000. These included chemical enrichment experiments, plutonium separation, and laser enrichment experiments. Only gram quantities of material were involved. The Government of the Republic of Korea stated that these activities had been carried out by "rogue scientists" without the knowledge of the national safeguards authority and without government authorization.[78]

The IAEA Board concluded that the failure to report these activities was a serious concern but noted that the quantities of nuclear material involved were not significant. The Board welcomed the corrective actions taken by the authorities in the Republic of Korea and its active cooperation with the IAEA to resolve all outstanding issues.

The Republic of Korea case demonstrated the strength of APs over the CSA alone: a number of the undeclared activities had come to light as a result of environmental sampling by the IAEA and through the wider access rights provided by the AP.

This case also highlighted the importance of a strong and independent safeguards regulator.[79] At the time, the Republic of Korea's national safeguards authority was part of the research organization where the unauthorized experiments had been conducted, clearly not a situation conducive to effective regulation. In response to this situation, the Republic of Korea reorganized the regulation of its nuclear industry and passed new legislation, including the establishment of an independent regulator with strengthened powers.

EGYPT (CONSIDERED BY THE IAEA BOARD IN 2005)

In the case of Egypt, undeclared nuclear activities were first revealed through the IAEA's information collection and analysis activities, when safeguards staff identified information in scientific publications indicating activities and materials that Egypt had not reported in its safeguards declaration.[80] Subsequent investigations by the IAEA revealed a number of undeclared experiments involving uranium conversion, extraction of uranium from phosphates, uranium and thorium irradiation experiments, and reprocessing experiments. Many of these pre-dated Egypt's CSA, which entered into force in 1982. Egypt explained that these past reporting failures were due to a lack of understanding of its obligations under the safeguards agreement, particularly as only very small quantities of nuclear material were involved.

Egypt's activities were reported to the IAEA Board in November 2004. The Board concluded that, while the safeguards failures were a matter for concern, they only represented shortcomings in safeguards regulation and reporting by Egypt. Further undeclared activities came to light between 2007 and 2008, along with the discovery of additional nuclear material previously undeclared to the Agency (including HEU

78. See IAEA, Implementation of the NPT Safeguards Agreement in the Republic of Korea, GOV/2004/84, 11 November 2004, https://www.iaea.org/sites/default/files/gov2004-84.pdf.
79. In IAEA terminology, a national safeguards authority is known as an SSAC, or State System of Accounting for and Control of Nuclear Material.
80. T. Findlay, Proliferation Alert! The IAEA and Non-Compliance Reporting, p. 75.

particles).[81]

Egyptian authorities cooperated with the IAEA in resolving the failures once they were detected. Egypt refuses to conclude an AP, which would be the best way to reassure the international community that no other undeclared nuclear activities exist in Egypt.

The lessons from the Egyptian situation include the critical importance for states to have an independent, competent and properly resourced national safeguards authority. Most importantly, in the absence of an AP, the IAEA is not in a position to conclude there are no undeclared nuclear materials and activities in the state as a whole.

B. Joint Comprehensive Plan of Action

This paper addresses only the JCPOA's potential relevance to verification of the Middle East zone.

The JCPOA was designed to ensure that the Islamic Republic of Iran's potential breakout time — that is, the time needed to produce sufficient nuclear material for a nuclear weapon — is at least one year.

Broadly speaking, the JCPOA provides for two categories of verification:

- Verification that all nuclear material is declared, accounted for and in peaceful use. This is essentially a reiteration of the provisions in the Islamic Republic of Iran's CSA and AP.

- Verification of transparency and confidence-building measures. These measures include agreed limits on enrichment levels and inventories of nuclear materials, and agreed restraints in R&D activities and deployment of centrifuge types, which goes beyond the NPT, the CSA and the AP. Observance of a number of these limits, particularly those relating to enrichment operations, could be readily verified by IAEA inspectors during routine safeguards procedures. Others required the expansion of IAEA activities beyond its routine procedures.

While these limits on certain nuclear activities go beyond technical safeguards measures as set out in the CSA and the AP, they serve a vital safeguards purpose by increasing the ability of the IAEA to provide timely warning in the event of misuse of nuclear material and facilities. These are particularly important in a situation of mutual mistrust, as is the case in the Middle East.

In the first category, verification of peaceful use, the JCPOA adopted important elaborations to improve safeguards effectiveness. One example is the application of accountancy to the manufacture of centrifuge components, an improvement on the

81. The relevant IAEA reports have not been released. See P. Goldschmidt, The IAEA Reports on Egypt: Reluctantly?, Carnegie Endowment for International Peace, 2 June 2009, https://carnegieendowment.org/2009/06/02/iaea-reports-on-egypt-reluctantly-pub-23200.

corresponding provision in the Model Additional Protocol.[82] Whether this is relevant to the Middle East zone depends on whether such manufacturing will be permitted in the zone.

Another important example where the JCPOA goes beyond the CSA and AP relates to dual-use items and activities that could contribute to nuclear weapon design and development (*weaponization*). Weaponization is prohibited for NNWSs by the NPT, but there is no formal definition for NPT or safeguards purposes. Because a number of weaponization activities are dual use, their intended purpose may well be ambiguous. There has been a long-running discussion about the extent to which IAEA safeguards encompass weaponization activities if no nuclear material is involved.[83] The JCPOA provisions are the first time weaponization activities have been defined in an international safeguards-related instrument.[84]

Under the JCPOA, certain activities that would fall under weaponization activities can be undertaken for non-nuclear purposes, subject to monitoring, if approved by the JCPOA's Joint Commission. Another interesting and potentially important provision in the JCPOA is for the Joint Commission to operate a procurement channel to review and decide on proposals to transfer items controlled by the Nuclear Suppliers Group.[85] In summary, the JCPOA addresses a number of areas that are not routinely covered by IAEA safeguards, including:

- The setting of qualitative and quantitative limits on the production of nuclear materials and the development and deployment of nuclear technologies – such limits are not part of the IAEA safeguards system. Indeed, the NPT is expressed in permissive terms, referring to the "inalienable right" of states to use nuclear energy for peaceful purposes, provided such use is in conformity with the treaty.[86]

  The problem is there is no international understanding on how the NPT should be applied in circumstances where the development of fissile material production capabilities could threaten the NPT's objectives; see the discussion of nuclear latency in Annex I.

- Elaboration of measures applying to nuclear-related manufacturing and imports.

- Elaboration of measures applying to potentially weaponization-related activities.

These areas should be considered for appropriate coverage in the arrangements for a Middle East NWFZ.

82. For manufacturing of items such as centrifuge components, the AP allows for observation and examination of production and shipping records but not accountancy as such. Compare the JCPOA, annex I, section R, with IAEA, INFCIRC/540 (Model Additional Protocol), articles 2.a(iv), 5.b and 6.c.
83. See J. Carlson, R. Leslie and A. Berriman, Nuclear Weaponisation Activities: What is the Role of IAEA Safeguards?, Annual Meeting of the Institute of Nuclear Materials Management, Nashville, 2006, https://www.belfer-center.org/sites/default/files/legacy/files/uploads/INMM2006_weaponisation.pdf.
84. See JCPOA, annex I, section T.
85. See JCPOA, annex IV, section 6.
86. NPT, article IV.

C. Elimination of South Africa's nuclear weapons

South Africa had operated a secret nuclear weapon programme from the 1970s, which included the development of an indigenous enrichment process[87] for the production of HEU. South Africa produced six nuclear weapons and the HEU for a seventh. In 1990, the incoming president, F.W. de Klerk, terminated South Africa's nuclear weapon programme (still secret at that time). The nuclear weapons were all dismantled and the recovered HEU placed in storage. In 1991, South Africa joined the NPT as a NNWS and concluded a CSA with the IAEA. South Africa declared its HEU inventory to the IAEA as part of its nuclear material inventory but did not explain why it had this material. Under the CSA, there was no requirement to declare past activities, just current fissile material holdings. This has changed in contemporary safeguards practice: a thorough understanding of a state's past nuclear activities is considered an essential aspect of drawing a conclusion on whether the state may have continuing undeclared nuclear activities.

In 1991, IAEA inspectors initiated verification activities to confirm that South Africa's physical inventory of nuclear material matched its declaration. The IAEA did not verify South Africa's dismantlement process, as South Africa conducted this unilaterally and did not declare its past programme. Yet confirming South Africa's nuclear material physical inventory was a complex task owing to the extensive nature of South Africa's nuclear fuel cycle and the years it had been operating and because some of the facilities were of unique design, never previously safeguarded by the IAEA. The task required considerable inspection resources and extensive cooperation by South African authorities in providing access to defunct facilities and historical operating records. The IAEA's first verification report, submitted in September 1992, did not mention any indications of a past weapon programme, though it concluded that there were "apparent discrepancies" in the calculated U-235 isotope balances at the Pilot Enrichment Plant and the Semi-Commercial Enrichment Plant.

In March 1993, President de Klerk publicly announced that South Africa had had a nuclear weapon programme and had dismantled it before joining the NPT. This prompted the IAEA to augment its safeguards team in South Africa with, among other specialists, nuclear weapons experts. The team's mandate was expanded to include assessing the status of the former nuclear weapon programme and to provide assurances that this programme had been completely terminated and dismantled. For these purposes, the IAEA had to determine that:[88]

- All nuclear material in South Africa had been placed under IAEA safeguards and remained in peaceful use.
- All nuclear weapons, their components, and related manufacturing equipment had been destroyed.

87. Helikon vortex isotopic separation.
88. For a more detailed account, see A. von Baeckmann, G. Dillon and D. Perricos, Nuclear Verification in South Africa, IAEA Bulletin 1/1995, https://www.iaea.org/sites/default/files/publications/magazines/bulletin/bull37-1/37105394248.pdf.

- All nuclear weapons-related installations had been fully decommissioned or converted exclusively to non-nuclear use or peaceful nuclear use.

- Mechanisms were put in place to ensure early detection of restoration of any nuclear weapons capability.

South African authorities provided access to all facilities the team requested to visit, as well as detailed shift-by-shift operating records and stage operation logs for the entire 15 years of operation of South Africa's HEU enrichment plant (the "Y-Plant"). In 1992, the IAEA was able to report that the Y-Plant had been decommissioned and partly dismantled. With the expanded mandate, South Africa also provided historical flows and balances, as well as information on the production and transfers of nuclear material. Some records dated back to the 1970s and, fortunately, had not been destroyed. To ensure the records were authentic, South Africa allowed inspectors to send away a sample of the records for forensic analysis.

The IAEA traditional U-235 material balance approach was insufficient in establishing the completeness of South Africa's declaration because the South African material accountancy system lacked formal measurement controls for depleted uranium. Detailed records had been kept for operational reasons to help manage process problems, not to facilitate future verification. However, these detailed records, coupled with the extraordinary access to Y-Plant operators and personnel that South African officials granted inspectors, were essential to facilitating the IAEA's completeness assessment. Inspectors were able to conclude that the quantity of HEU declared to have been produced by the Y-Plant was consistent with the plant's production capacity.

More time and effort were needed to resolve apparent discrepancies in the production of LEU at South Africa's second enrichment plant, the Z-Plant, which was operated on a semi-commercial basis to fuel the two Koeberg power reactors. Inaccurate accounting records for the depleted uranium tails made it difficult to calculate the correct isotopic balance for the ZPlant. It appeared that some U-235 was missing. Detailed scrutiny of the daily operating records, together with sampling of the depleted uranium stocks, showed that the U-235 content of the tails was higher than recorded in the material accounts. This was where the apparently missing U-235 had gone. Eventually, the IAEA was satisfied that the quantity of LEU produced was correctly reported.

In late 1994, after conducting more than 150 inspections, the IAEA reported that it had found no reason to doubt the veracity of South Africa's initial declaration of nuclear material placed under safeguards. However, the IAEA also noted that its assessment of the completeness of South Africa's inventory of nuclear facilities and materials and its assessment of the status of the former nuclear weapon programme — as in all cases where a large nuclear programme first comes under safeguards — was not free from uncertainty.

Indeed, many years later, in order to reach the broader conclusion under the IAEA's strengthened safeguards system that all nuclear material in South Africa remained in peaceful activities (a conclusion finally reached in 2010), the IAEA revisited the question of the U-235 content in depleted uranium tails. Because there were tens of thousands

of drums of tails in 1994, the IAEA had analysed a selection of the drums. Now, to ensure the 1994 conclusion was soundly based, every drum was opened and analysed.

The lessons from the experience of verifying the elimination of South Africa's nuclear weapon programme include the substantial inspection resources required, the need for dedicated inspectors from NWSs, the amount of time required (well over a decade), and the need for full cooperation by the state concerned. Especially important was South Africa's policy of transparency: South Africa issued the IAEA a standing invitation for full access to any location or facility associated with the former nuclear weapon programme and access to any locations the IAEA may have a reason to visit – "access any time, any place with a reason". Also important was South Africa's willingness to provide inspectors with access to individuals who had worked in the weapon programme. For future cases, there is no doubt that verification of the dismantlement process, rather than verification post hoc, would enable inspectors to reach quicker and more definitive verification conclusions.

The South African case also demonstrated that even with the full cooperation of the state, reaching a nuclear material balance for a nuclear weapon programme is a major challenge, and it can be expected that substantial ambiguities, inconsistencies and gaps will remain for some time. Ultimately, a final judgment may have to be based on the level of cooperation and transparency demonstrated by the state and the comfort level of living with inconclusive conclusions.

Nuclear Verification in a Middle East WMD Free Zone

Lessons from Past Verification Cases and Other Precedents

Verification will be of critical importance to achieving and maintaining a Middle East zone free of weapons of mass destruction (ME WMD). Effective verification arrangements would serve a vital national security objective for each state in the region by reducing tensions, removing the motivation to proliferate, and mitigating the risk of a virtual nuclear arms race (or war). In view of the high levels of tension and mistrust within the zone, ensuring effective verification will be especially demanding. The paper examines specific elements of the future nuclear verification of the zone, including: Which states should be included? What prohibitions and obligations should apply in the zone and how would they be verified? How could elimination of nuclear weapons in the zone be achieved? On what basis would the zone treaty enter into force?

The paper also examines a number of existing treaties and arrangements as well as the lessons learned from past verification cases which regional states can draw on in developing verification for a Middle East nuclear-weapon-free zone.