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A Collection of Fellowship Research Papers



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CTBTO RESEARCH FELLOWSHIP

A Collection of Fellowship Research Papers

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The CTBTO Research Fellowship was launched in 2021 and organized in cooperation with the Center for Energy and Security Studies (CENESS) to help promising young scholars build their professional networks by giving them access to top professionals and experts in the field of nuclear disarmament and nonproliferation. The Fellows were invited to attend a series of webinars lectured by prominent experts and diplomats, conduct research on CTBT, nonproliferation, and disarmament issues, and engage with distinguished scholars and practitioners.

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The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) was established in 1996 with its seat in Vienna. Its main tasks are promoting the Comprehensive Nuclear-Test-Ban Treaty and building the verification regime to ensure its operational readiness when the Treaty enters into force. The Commission is headed by the Executive Secretary, Dr. Robert Floyd. The CTBTO Youth Group (CYG), launched in January 2016, is open to students and young professionals dedicated to achieving the entry into force and universalization of the CTBT. By March 2025, the Group had grown to over 1,650 members from over 130 countries.

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The Center for Energy and Security Studies (CENESS) is an independent, non-governmental think tank established in 2009. Headquartered in Moscow, CENESS's main goal is to promote independent, unbiased, systematic, and professional analyses on nuclear nonproliferation, arms control, and atomic energy. The flagship project of CENESS is the Moscow Nonproliferation Conference, which includes the New Generation Experts Segment, typically organized every 24 months. The Director of the Center is Anton Khlopkov.

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CTBT at 30: Achievements, Risks and Opportunities

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ABSTRACT

As the Comprehensive Nuclear-Test-Ban Treaty (CTBT) approaches 30 years since its opening for signature, it remains a cornerstone of the global commitment to nuclear disarmament and non-proliferation. Although the Treaty has yet to enter into force, its substantial accomplishments underscore its critical role in advancing global security, peace, and environmental protection. In this article, we delve into the remarkable journey of the CTBT, highlighting its achievements since its inception and the risks and opportunities that the CTBT community should consider as it nears its 30th anniversary in 2026. We explore the Treaty's successes in preventing all types of nuclear explosions and the notable achievements of the Preparatory Commission while acknowledging the significant challenges and emerging risks it faces in today's complex geopolitical landscape. Additionally, we discuss new opportunities and recommendations to strengthen the CTBT's role in global safety, environmental protection, and scientific collaboration. To enrich this analysis, we interviewed individuals directly involved in the CTBT's critical negotiation phase, providing unique perspectives and deeper insights into the Treaty's evolution. By examining its milestones, risks, and future potential, we underscore the CTBT's enduring significance as a bulwark against nuclear testing and a pivotal contributor to a more secure, sustainable and peaceful world.

INTRODUCTION

This article aims to highlight the **achievements** and **risks** associated with the Comprehensive Nuclear-Test-Ban Treaty (CTBT), identify **opportunities**, and provide **recommendations** regarding this treaty and the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). It will discuss the main topics related to these four aspects in separate sections.

In the section on **30 Years of Achievements**, we emphasize the near-universal support for the CTBT, which has 187 signatories, 178 out of which have also ratified it. This treaty has been crucial in promoting a world free from nuclear tests, as only six nuclear tests have occurred in the 21st century, all conducted by North Korea. The establishment of hundreds of monitoring stations worldwide enables the immediate detection of any activities that may indicate a nuclear test. This capability is vital for preventing nuclear proliferation, reinforcing the treaty's role as an essential pillar of the Non-Proliferation Treaty (NPT).

In the second section, we examine certain **risks** associated with the CTBT. Geopolitical tensions and ongoing conflicts may raise concerns about the potential for a nuclear test, which could serve as a demonstration of intent to utilize nuclear capabilities or contribute to the challenges of nuclear proliferation. Additionally, serious concerns exist regarding allegations related to activities that could indicate preparations for the resumption of nuclear tests, particularly the development of low-yield nuclear weapons, defined as those below 0.5 kilotons. These issues highlight the importance of continuously enhancing and

investing in the International Monitoring System (IMS) stations, alongside maintaining high professional training standards.

We conclude the article with a section on **Opportunities and Recommendations** for the CTBT's Upcoming Anniversary. In this section, we propose that the CTBTO advocate for states to uphold their commitments to refrain from nuclear tests and highlight its potential to serve as a foundation for establishing new nuclear weapons-free zones worldwide. We also stress the importance of promoting public awareness of the risks associated with nuclear weapons testing, particularly by engaging with youth and global civil society. Additionally, we underscore the significant role of the CTBTO as a crucial tool for achieving the United Nations (UN) Sustainable Development Goals (SDGs).

To enhance our analysis, we consulted key individuals who were instrumental during the negotiation phase of the Treaty. Their valuable insights provide profound perspectives on the Treaty's development. By examining its significant milestones, inherent challenges, and future possibilities, we underscore the CTBT's vital role as a strong safeguard against nuclear testing and as an essential pillar in promoting a more secure, sustainable, and peaceful global community.

Reflections after 30 years: Interviews with Ambassadors involved in the CTBT negotiations

One of the approaches taken during the research process for this article was to reach out to individuals directly involved in the CTBT negotiations, in the hope that their insights after three decades of reflection could be shared as a resource for younger generations who continue to promote the Treaty. We spoke with Ambassador Abdelkader Mesdoua of Algeria (via email on 29 October 2024), Ambassador Grigory Berdennikov of the Russian Federation (via Zoom on 29 October 2024), and Ambassador Paul O'Sullivan of Australia (via Zoom on 5 November 2024). Excerpts from these interviews are shared throughout this article to enrich the discussion.

30 YEARS OF ACHIEVEMENTS

Despite a highly regrettable delay with its entry into force, the CTBT has made remarkable progress, establishing a robust verification system, fostering scientific and technological advancements, and uniting countries under a shared vision for a nuclear-test-free world. These achievements underscore the Treaty's pivotal role in global security and environmental protection and its capacity to adapt to emerging challenges and inspire future generations.

Since its adoption in 1996, the CTBT has significantly promoted nuclear disarmament and global security. The Preparatory Commission for the CTBTO established an unparalleled verification tool: an extensive International Monitoring System (IMS).¹ The IMS remains one of the most sophisticated and comprehensive global monitoring networks. Consisting of over 300 stations across all continents, this system uses seismic, hydroacoustic, infrasound, and radionuclide technologies to detect and verify any nuclear test activity. The IMS has proven its capacity in real-world scenarios, detecting tests conducted by the Democratic People's

¹ CTBTO official web-site, The International Monitoring System, https://www.ctbto.org/our-work/ international-monitoring-system/, accessed 1 March 2025>.

Republic of Korea (DPRK), including a test below one kiloton in 2006.² The International Data Centre (IDC)³ supports this network, processes and analyzes the data collected from IMS stations. The IDC operates continuously at the CTBTO headquarters in Vienna, providing near real-time data to the Member States. The IDC's role is crucial for nuclear verification and transparency: it distributes data in raw and analyzed forms, allowing states to verify nuclear events independently. The IDC also produces automated and human-reviewed event bulletins, helping Member States interpret events quickly and accurately. The IMS and IDC have a twofold impact:

1. The IMS and IDC ensure that nuclear tests activities are immediately detected. Their data also support disaster response and research, including providing critical information for tsunami early-warning systems and aiding earthquake monitoring.

2. The dual use capacity of IMS data for security and civil applications underscores the CTBT's broader value to global safety and scientific research, strengthening its role in fostering a safer, more secure world.



Figure 1. The CTBTO/PC has made steady progress since 2000 in establishing and certifying IMS facilities (as of December 2023, 292 sensor stations and 16 radionuclide laboratories). This data comes from CTBTO/PC Annual Reports (2000-2023) and counts facilities installed and certified by the end of each year.

The CTBT's emphasis on collaborative efforts for non-proliferation has also fostered partnerships with numerous international organizations, contributing to broader arms control and non-proliferation efforts. Such collaborations include the International Atomic Energy Agency (IAEA), as the CTBTO Preparatory Commission and the IAEA share a common

² CTBTO official web-site, 2006 DPRK Announced Nuclear Test, <https://www.ctbto.org/our-work/detecting-nuclear-tests/2006-dprk-nuclear-test/, accessed 5 February 2025>.

³ CTBTO official web-site, The International Data Center, <https://www.ctbto.org/our-work/international-data-centre/, accessed 1 March 2025>.

goal of preventing nuclear proliferation.⁴ The United Nations Office for Disarmament Affairs (UNODA) actively supports the CTBT through advocacy and diplomatic channels, promoting



conducted before and after the CTBT opened for signature on 24 September 1996. ratification efforts and reinforcing the Treaty's importance in disarmament discussions.⁵ The CTBTO provides IMS data to the World Meteorological Organization (WMO), supporting advancements in climate studies, weather prediction, and disaster response, thus enhancing scientific collaboration beyond nuclear testing.⁶ Moreover, through the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE),⁷ the CTBTO provides valuable radionuclide data, aiding international responses to radiological emergencies, such as the Fukushima incident in 2011.⁸ These collaborations enhance the Treaty's verification capabilities and underscore its relevance beyond arms control, linking nuclear test monitoring with broader international goals. Although the Treaty awaits ratification by a few Annex 2 states, it has garnered near-universal support, underscoring almost the global consensus

on the need to eliminate nuclear testing as a step towards a safer, nuclear-free world.

Finally, nuclear testing poses severe risks to the environment and public health,⁹ and the CTBT has helped mitigate these dangers by drastically curtailing the frequency of nuclear detonations. Its contributions align with the United Nations (UN) Sustainable Development Goals (SDGs) such as SDG 16 (Peace, Justice, and Strong Institutions) and SDG 13 (Climate Action). By monitoring nuclear tests worldwide, the CTBT helps protect ecosystems from the environmental harm of nuclear testing, especially in oceanic and terrestrial habitats.

⁴ Statement to the 67th regular session of the General Conference of the International Atomic Energy Agency of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, 25-29 September 2023, <https://www.iaea.org/sites/default/files/23/09/ctbto-gc67.pdf/, accessed 6 February 2025>.

⁵ CTBTO official web-site, UN Disarmament Fellows at the CTBTO https://www.ctbto.org/news-and-events/ news/un-disarmament-fellows-ctbto/, accessed 6 February 2025>.

⁶ CTBTO official web-site, CTBTO-WMO, the Way Forward <https://www.ctbto.org/news-and-events/news/ ctbto-wmo-way-forward/, accessed 6 February 2025>.

⁷ The IACRNE first came into existence in 1986 after the Chernobyl nuclear disaster. The members of the IACRNE, currently eighteen international organizations, work together to develop and maintain the Joint Radiation Emergency Management Plan of the International Organisations. The IAEA is the main coordinating body for development and maintenance of the Joint Plan. The CTBTO formally joined IACRNE in 2012 after the Fukushima disaster. Under the mandate of the Joint Plan, the intention is to support "the efforts of national governments and ensure a coordinated and harmonized international response to nuclear or radiological emergencies." For more information on the Joint Plan see "Joint Radiation Emergency Management Plan of the International Organisations," IAEA, 2017, https://www.iaea.org/publications/11163/joint-radiation-emergency-management-plan-of-the-international-organizations.

⁸ Robert Floyd, "25 Years of CTBTO", In: Cotta-Ramusino, P., Lowenthal, M., Maiani, L., Pellecchia, E. (eds) Nuclear Risks and Arms Control - Problems and Progresses in the Time of Pandemics and War, August 2023, p. 12 <https:// link.springer.com/chapter/10.1007/978-3-031-29708-3_2/, accessed 6 February 2025>.

⁹ United Nations Scientific Committee on the Effects of Atomic Radiation, Sources, Effects and Risks of Ionizing Radiation UNSCEAR 2020/2021 Report, https://www.unscear.org/unscear/uploads/documents/unscear-reports/UNSCEAR_2020_21_Report_Vol.I.pdf, accessed 6 February 2025>.

Last but not least, the CTBT has already made a vital contribution to the building of the global legal norm against nuclear testing, because, in accordance with the international law, signatories to a treaty are bound not to take actions that run counter to the object and purpose of that treaty; hence a nuclear test by any of the 187 states signatories to the CTBT would be unlawful, even if the CTBT has not yet entered into force. Furthermore, this situation helps provide an additional measure of sustainability to the current moratorium on nuclear testing.

The CTBT's achievements over the past three decades highlight its enduring significance as an important pillar of global security and non-proliferation. The CTBT has established itself as an indispensable force in preventing nuclear testing and its associated risks. However, the pathway to full implementation still needs to be completed. As the CTBT approaches this 30th milestone anniversary, it is essential to celebrate these accomplishments and confront the remaining challenges.

What do the Ambassadors highlight as the CTBT's key achievements thus far?

Amb. Berdennikov: The Preparatory Commission is doing a marvelous job... The verification system is ready.

Amb. Mesdoua: Although the CTBT has not yet entered into force, it has still achieved significant milestones. It has established a global norm against nuclear testing, contributing to a substantial reduction in the frequency of nuclear tests since its adoption. The CTBT has also fostered dialogue among countries on nuclear disarmament and non-proliferation.

Amb. O'Sullivan: You can think of treaties along two lines: one is as temporary legal mechanisms to enforce, the other is distilling a political and strategic consciousness, and that's the case with the CTBT. There does not seem to have been any broad, political hostility to the CTBT.

And the key risks facing the Treaty and its Preparatory Commission today?

Amb. Berdennikov: 30 years is a long time, and the situation of the world is not what it was. Frankly speaking, I am afraid people might lose their patience with this treaty, and some might even want to stop paying their dues to the Preparatory Commission...If this treaty fails, we may as well say goodbye to nuclear arms control for a generation.

Amb. O'Sullivan: [Paraphrased] I see three possibilities as the largest risks for the CTBT. The first is of a nuclear power going through some strange spasm of withdrawing from treaties and giving into an argument that testing has somehow become necessary. The second is of deteriorations in several regions, namely in the Middle East and Northeast Asia. The third is of a collapse in public support, but I can't really see that happening.

Amb. Mesdoua: Key obstacles include the lack of ratification by pivotal states, persistent political tensions in regions such as the Middle East, Southeast Asia, and the Korean Peninsula, and the ongoing war between Russia and Ukraine. Like all international institutions, the Preparatory Commission, along with its monitoring capabilities, encounters financial and operational hurdles that could impede the effectiveness of the verification system.

RISKS IN A CHANGING WORLD

In this section, we will examine the risks faced by the CTBT, particularly regarding the resurgence of nuclear weapons tests and the risk of "desertion" of States from this treaty. Key challenges include geopolitical tensions in Europe, the Middle East, East Asia, and South Asia and competition among the United States (US) against Russia and China. Another significant challenge is the need to enhance the IMS technical capabilities and provide advanced training for specialists to ensure the system can effectively detect potential attempts to bypass monitoring and address new technological and geopolitical developments. We will discuss these issues in more detail below.

The world is currently experiencing heightened geopolitical tensions due to the war in Eastern Europe, the crisis in the Middle East, and growing tensions in the Korean Peninsula. The situation in Ukraine has further strained relations between Russia and the North Atlantic Treaty Organization (NATO). Both sides are conducting military exercises with their nuclear forces, and, although those do not comprise the actual use of live weapons,^{10,11} there are concerns that escalating tensions could lead to misunderstandings and eventually to a dynamic in which nuclear detonations as a signaling mechanism or escalation pathway are not unthinkable.

In the Middle East, tensions are escalating between Israel and Iran due to the ongoing conflict in Gaza. There are concerns that Iran may pursue nuclear proliferation, prompting Israel to consider the use of nuclear weapons to halt Iran's nuclear program or to gain an advantage in any potential conflict between the two nations.¹² Such actions might lead to a nuclear proliferation effect in this part of the globe, as other countries in the region might consider obtaining nuclear weapons as well.

The growing competition between the US against Russia and China is becoming an increasing concern. While Washington and Moscow have reduced their nuclear arsenals, they continue modernizing their weapons, shifting focus from quantity to quality. Similarly, Beijing and London are also modernizing their nuclear forces and plan to increase their warhead numbers. What if these countries decide to test warheads for their new weapons systems or to demonstrate their readiness?¹³

Allegations have surfaced that China, Russia, and the US all have heightened levels of activity at former nuclear test sites, leading to some fear that this activity is linked to preparations for

¹⁰ Hans Kristensen, "NATO Tactical Nuclear Weapons Exercise And Base Upgrades", Federation of American Scientists, October 2024 https://fas.org/publication/nato-tactical-nuclear-weapons-exercise-and-base-upgrades/, accessed 20 February 2025>.

¹¹ Oman Al Yahya, "Vladimir Putin oversees large-scale nuclear response drills as tensions with NATO run high", Euro News, October 2024 https://www.euronews.com/2024/10/29/vladimir-putin-oversees-large-scale-nuclearresponse-drills-as-tensions-with-nato-run-high/, accessed 20 February 2025>.

¹² Matthew Kroenig, "The Case for Destroying Iran's Nuclear Program Now", Foreign Policy, October 2024, https://foreignpolicy.com/2024/10/03/israel-iran-nuclear-weapons-biden-netanyahu-destroy-now/, accessed 20 February 2025>.

¹³ Felipe Dalcin Silva, "O Vigente Processo de Desrespeito ao Tratado de Não-Proliferação Nuclear (TNP): Quem culpar?" Instituto Sul-americano de Política e Estratégia, February 2023: p. 2-9, <https://www.ufrgs.br/ppgeei/wp-content/uploads/2023/09/O-Vigente-Processo-de-Desrespeito-ao-Tratado-de-Nao-Proliferacao-Nuclear-TNP-Quem-culpar.pdf/, accessed 1 March 2025>.

the resumption of nuclear tests.¹⁴ The first Trump and Biden administrations have suggested that Russia may have executed low-yield nuclear tests – probably below 0.5 kilotons – and have raised concerns about China's compliance with zero-yield standards. Russia accused the US of similar actions, citing a suspicious activity at the Nevada National Security Site in October 2023.¹⁵ This situation is concerning as both nations are alleged to be developing new tactical nuclear weapons, particularly with the CTBT not in force and on-site inspections currently impossible. Voluntary test-site transparency visit initiatives between the three countries, which were unsuccessful even in a more peaceful past context, unfortunately, seem even further from reach today.¹⁶ Some figures connected with the previous administration of US President Donald Trump have advocated for enhancing the US nuclear arsenal and conducting related tests.¹⁷ In November 2023, Russia withdrew its ratification of the CTBT, citing the fact that the United States, while having signed the treaty, has not ratified it.¹⁸

There are geopolitical concerns related to the CTBT involving the relationship between Pakistan and India and the DPRK's nuclear developments. While neither Pakistan nor India has conducted a nuclear test since 1998, the situation could change during a geopolitical crisis, as either country might conduct a nuclear drill or test new warheads. If one conducts a test, the other is likely to follow. In the DPRK's case, further nuclear tests may be imminent as the country seeks to enhance its nuclear capabilities. If the DPRK conducts a nuclear test to demonstrate strength, there is a possibility that it could potentially encourage other States in the region, such as South Korea or Japan, to pursue nuclear proliferation.

One of the challenges the CTBTO faces is the need to expand and modernize its IMS worldwide and explore new technologies that can enhance its ability to detect nuclear tests. Accusations between Russia and the US about potential test ban transgressions or intentions to undermine the CTBT further highlight the urgency of these efforts. Given that formal onsite inspections are currently not feasible, it is crucial to update the technology for detecting any nuclear explosion, even if its yield is well below a kiloton. This is a complex challenge, requiring inputs from nuclear scientists, weapons designers and experts in other fields. Additionally, sustained professional training for international monitoring staff is essential to maintain operational excellence. To address these challenges effectively, Member States must continue to invest in and support the IMS.

The CTBT faces challenges from geopolitical tensions that could lead to nuclear weapon tests or even use. Such developments could undermine the CTBT and the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). Dr. Robert Floyd, Executive Secretary of the CTBTO, notes that the indefinite extension of the NPT in 1995 relied on establishing the CTBT framework.¹⁹ If tensions escalate, we could see increased nuclear proliferation and tests,

¹⁴ Jeffrey Lewis, "Nuclear Test Sites are Too Damn Busy", September 2023, <https://www.armscontrolwonk.com/ archive/1218750/nuclear-test-sites-are-too-damn-busy/, accessed 14 February 2025>.

 ¹⁵ Anastasia Malygina, Hanna Notte and Lynn Rusten, "The Risk of Renewed Nuclear Testing", August, 2024: p.3-6
https://deepcuts.org/publications/working-papers/the-risk-of-renewed-nuclear-testing/, accessed 1 March 2025>.
¹⁶ Frank von Hippel, "Transparency for nuclear weapons test sites", Physics Today 73(5) p.10-11, May 2020, https://

pubs.aip.org/physicstoday/article-pdf/73/5/10/10124066/10_1_online.pdf/, accessed 14 February 2025>.

¹⁷ Robert C. O'Brien, "The Return of Peace Through Strength: Making the Case for Trump's Foreign Policy," Foreign Affairs, July/August 2024, <https://www.foreignaffairs.com/united-states/return-peace-strength-trumpobrien/, accessed 17 November 2024>.

¹⁸ РИА Новости, "Путин подписал закон об отзыве ратификации ДВЗЯИ", <https://ria.ru/20231102/ dvzyai-1906891860.html/, accessed 5 February 2025>.

¹⁹ Robert Floyd, "25 Years of CTBTO", In: Cotta-Ramusino, P., Lowenthal, M., Maiani, L., Pellecchia, E. (eds) Nuclear Risks and Arms Control - Problems and Progresses in the Time of Pandemics and War, August 2023: p. 12, <https:// link.springer.com/chapter/10.1007/978-3-031-29708-3_2/, accessed 2 February 2025>.

threatening international security, the environment, human health, and so many more issues. Moreover, some states might explore ways to breach this regime to enhance or modernize their nuclear capabilities. Thus, improving the efficiency of the IMS is crucial to prevent these violations. That is why we all must focus on CTBT and work to bring it into force. The next section will explore some opportunities to strengthen this organization.

OPPORTUNITIES AND RECOMMENDATIONS FOR THE CTBT'S UPCOMING ANNIVERSARY

Though the treaty has yet to come into force as it requires ratification by all 44 Annex 2 states, the CTBT has shown significant success in ensuring that states refrain from carrying out, causing, or encouraging any nuclear weapon test explosion or any other nuclear explosion in any manner. The CTBTO Preparatory Commission should now look for new opportunities to build confidence among its members and, more importantly, non-signatories. Highlighting the critical role of this organization can help garner more support for its work and help this treaty enter into force.

As we approach the 30th anniversary of the CTBT opening for signature, how did you envision the treaty when you were involved in its negotiation, and how has it evolved differently over the years?

Amb. Mesdoua: Achieving a consensus on a document that would promptly enter into force was recognized as a challenging goal from the outset... Despite broad support, the treaty has faced obstacles to full implementation.

Amb. Berdennikov: Our hope at the time of negotiation was that the CTBT would start the process of multilateral arms control all over the world...but this never materialized.

Amb. O'Sullivan: In the almost 30 years since the treaty was opened for signature there have been a very limited number of tests. So [the CTBT's] vision, distinct from its provisions, seems to have been adequately realized.

While the treaty has achieved impressive progress on its core agenda, it can also assist in achieving several of the 17 UN SDGs.²⁰ Specifically, SDGs such as Sustainable Cities and Communities (11), Responsible Consumption and Production (12), Climate Action (13), Life Below Water (14), and Life on Land (15) can be more effectively attained if the CTBTO leverages its state-of-the-art IMS and IDC facilities for climate change mitigation. In this effort, the IMS can become indispensable since the System works around the clock to document nuclear explosions and pick up signals regarding natural events, such as earthquakes, tsunamis, volcano activities, etc. With 321 planned monitoring stations and 16 laboratories hosted by 89 countries around the world, the IMS can help 187 CTBT signatory states to instrumentalize the recorded data for disaster warnings and scientific studies. Alongside the IMS, the IDC should also be instrumental in providing up-to-date data. A close partnership between the CTBTO and the Sustainable Development Solutions Network (SDSN) can significantly contribute to these SDG initiatives. As an organization committed to a world free of nuclear tests, the CTBTO also supports Sustainable Development Goal 16, which focuses on peace, justice, and strong institutions by helping to strengthen indirectly

²⁰ United Nations "THE 17 GOALS" Department of Economic and Social Affairs Sustainable Development, https://sdgs.un.org/goals/, accessed 12 February 2025>.

the reliability of the NPT and can serve as an important pillar for the creation of Nuclear Weapons Free-Zones around the world.

As mentioned in the previous section, concerns persist about the risks associated with the ongoing arms race and the diminishing role of arms control mechanisms. As the CTBT enters its 30th year, it remains critical to focus on its core objective of preventing nuclear tests, thereby reducing the risks associated with nuclear weapons development and the escalation of nuclear threats.

Due to the CTBT's relevance to existing and emerging non-proliferation challenges, its mandate must be communicated at the highest political levels. Additionally, the importance of the CTBT should be highlighted for global civil society, particularly in addressing suspicions about certain clandestine nuclear activities. There is a good recent example illustrating this point: in October 2024 there were allegations that Iran conducted one or two nuclear tests. Given the current controversy around the Iranian nuclear programme, such allegations had a potential of provoking an acute crisis. But with the information quickly collected by the IMS, it was clarified that what occurred in Iran was two earthquakes.²¹ In the context of the political and geopolitical crises in the Middle East, such information is essential to avoid escalating tensions. Regrettably, though, the vast majority of comments and articles on this episode, published and posted on a variety of platforms, while confirming the earthquake story, failed to mention the role of the IMS and the CTBTO in certifying the correct explanation.

What lessons from the original CTBT negotiations could be used to promote the treaty in the present day?

Amb. Mesdoua: Valuable lessons that can be applied to promote the treaty include: engaging all stakeholders (both nuclear and non-nuclear states) in open and genuine dialogue, addressing security concerns of states (especially those that rely on nuclear deterrence) to build trust and facilitate progress toward ratification, partnering with civil society – public support can increase pressure on governments to ratify the treaty, and leveraging regional conferences (such as the African Union, Arab League, ASEAN, and OAS) to elevate the CTBT's visibility.

Amb. Berdennikov: Young diplomats need to experience major negotiations, and there is no other place for multilateral negotiations quite like arms control. In the [CTBT] negotiations, we had not only the experience of working with 50 more countries who had joined the Conference on Disarmament at that time, but also we had to have weekly meetings of the P5 to coordinate our policies – we had to know and understand each other's positions to see the limits of what was possible during the discussions.

Amb. O'Sullivan: The CTBT benefitted from the momentum of the CWC; it was a key. moment when the stars lined up for arms control and analogous treaties. There is no simple answer as to whether you should wait for the right conditions, or grab history by the shoulder and give it a shove, because it depends on so many factors. But when it is strategically possible to get something done, you must seize the moment.

²¹ CTBTO, "CTBTO detects two earthquakes in northern Iran on 5 October", CTBTO Preparatory Commission, October 2024, https://www.ctbto.org/news-and-events/news/ctbto-detects-two-earthquakes-northern-iran-5-october/, accessed 12 February 2025>.

According to the UN, the global population of youth aged 15 to 24 is expected to reach approximately 1.3 billion by 2030. This underscores the importance of engaging with the world's youth to achieve a sustainable future. The CTBT has an opportunity to revitalize its intergenerational dialogue, promoting broader participation and training young people in the basics of negotiations and consultative mechanisms.

Youth engagement has historically been a powerful asset for the CTBT, with the CTBTO Youth Group (CYG) once serving as a vital platform for mobilizing young advocates and counting to more than 1,200 members.²² Through programs like the CYG Introductory Curriculum, young people worldwide have gained foundational knowledge about the Treaty, its verification system, and the importance of non-proliferation, supporting SDG 4, related to education. Enhancing the efficiency and activity of the CYG is essential to fully leverage its potential. By making the CYG more active and impactful, one can strengthen global efforts to promote the CTBT's objectives and foster greater engagement among youth in shaping a nuclear-test-free future. Reactivating the CYG would empower young people to lead awareness initiatives, especially in Annex 2 countries, building public support for ratification. Youth could bring fresh perspectives and creative strategies that would help overcome long-standing political barriers to the Treaty's entry into force.

Finally, the CTBTO has accomplished something truly remarkable in the establishment and operation of the IMS and IDC, and continued preparations of the On-Site Inspection (OSI) mechanism. Signatory states have supported this work for nearly three decades despite an extended wait for the CTBT's entry into force, and this support has clearly continued. This is a promising sign, but there are worries that financial support for the CTBTO may wane as states lose patience awaiting the treaty's ratification or assume that the fast-approaching completion of the remaining IMS stations to reach the 321 specified by the CTBT entails a slowing down of activity for the Preparatory Commission. The IMS and IDC require ongoing maintenance and updates to ensure the continuation of the system's demonstrated capability and further improve the stations' ability to detect very low-yield explosions. States could further increase confidence by building towards voluntary test site transparency measures while awaiting the treaty's entry into force and the OSI mechanism.²³ State signatories must continue to support the CTBTO Preparatory Commission in its activities, and publicly reaffirming their commitments on the 30th anniversary could serve as a powerful political signal and trust-building exercise.

Here, we highlight several opportunities where the CTBTO and its Member States could make a significant impact in promoting the Treaty's entry into force:

1. Nuclear-weapon states could issue joint or individual statements reaffirming their commitment to the moratorium and ongoing support to the CTBT and its early entry into force. These statements would allow each state to articulate its perspectives and conditions for ratification. While differences in positions may persist, such documents have the potential to reinvigorate dialogue, build mutual understanding, and create momentum toward breaking the current impasse.

²² CTBTO official web-site, CTBTO Youth Group, <https://www.ctbto.org/resources/for-civil-society/ctbto-youth-group & https://youthgroup.ctbto.org/, accessed 1 March 2025>.

²³ Hugh Chalmers and Hailey Wingo, "Enforcing the CTBT: The Role of Consultation and Clarification", VERTIC, May 2024, https://www.vertic.org/wp-content/uploads/2024/05/PUBLISHED-VERSION-EnforcingTheComprehe nsiveNuclearTestBan-May24-2024.pdf/, accessed 1 March 2025>.

2. Organizing special conferences and/or a series of regional workshops, particularly those that engage Annex 2 countries and focus on youth, can play a crucial role in highlighting the importance of the CTBT. These events provide platforms for dialogue, education, and advocacy. When combined with the enhanced efficiency of the CYG, these initiatives could have a lasting impact by inspiring and empowering the next generation of leaders and advocates, potentially influencing ratification efforts and strengthening support for the Treaty in the future.

3. Drafting and advocating for strong language in the final document of the 2026 NPT Review Conference to promote the CTBT's entry into force. Such language might reaffirm the commitment of all parties to maintaining the moratorium on nuclear testing, emphasize the importance of universal ratification of the CTBT, and call on the Annex 2 states to complete their ratification processes. It would be highly advisable if the Executive Secretary of the CTBTO receives a mandate to prepare a draft program of action to be approved and hopefully implemented by the time of the next NPT Review Conference, containing a limited number of important but achievable objectives, supporting the momentum towards the entry into force of the Treaty. Implementation of such a program would not only help the CTBT, but also contribute to a more productive NPT Review Conference in 2026.

4. As an organization, the CTBTO Preparatory Commission should focus on raising awareness about the dangers of nuclear testing. Collaborating with international media is essential for informing the global population about the risks associated with nuclear tests. This can be done both by inviting press from large, conventional media outlets to events hosted by the CTBTO, and by looking to less traditional news media and social media to reach younger audiences as well. Such platforms lend themselves well to visually engaging materials; short-form videos adapting materials already developed by the CTBTO or a documentary commemorating the 30th anniversary may be useful initiatives for consideration. Narratives should include not just information on the Treaty itself, but also its benefit to human health and the environment and avenues for further engagement and advocacy. Through increased awareness, individuals can be empowered to encourage their countries to respect the Treaty and collaborate more with the CTBTO. This effort is crucial for the citizens of the 9 Annex 2 states that still need to ratify or sign and ratify the CTBT, enabling them to advocate for their countries to do so.

N5: Possible Steps and Actions to Consolidate Non-Testing Norm and Facilitate the CTBT Entry into Force

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ABSTRACT

In the current international security context, the hope for a speedy entry into force (EIF) of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) has dwindled. To achieve this end and ensure that non-testing norm is maintained, it is essential for the five nuclear-weapon states as recognized in accordance with the Nuclear Non-Proliferation Treaty (NPT) – China, France, Russia, the United Kingdom, and the United States of America – to work together to enhance trust in one another and the work of the Treaty. This paper details a number of recommendations for the "Nuclear Five" (N5) to consider, namely the issuance of statements reaffirming their commitment to the Treaty and the non-testing norm, confidence-building, monitoring and verification exercises, the provision of financial and technical resources to support the establishment and operation of the International Monitoring System (IMS), a commitment to engagement with remaining Annex 2 States for entry into force, and educational initiatives.

INTRODUCTION

At this crucial moment in the international security environment, the entry into force of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) seems like a distant milestone, with the prospect of resumption of nuclear testing looming larger than ever. Notably, there are growing concerns that the new Trump administration may consider reversing the American unilateral testing ban moratorium, given that prominent Trump advisors have advocated for a resumption of nuclear weapon tests.¹ This exacerbated the growing tensions within the international community regarding the non-testing norm, especially after Russia's "deratification" of the CTBT. In spite of the Treaty's pivotal role in facilitating an almost universal taboo on nuclear testing, action is needed to reinvigorate the path toward its EIF and to ensure the continuation of the work of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), which brings numerous benefits for the safety and security of the international community. This will be impossible to achieve without the efforts and leadership (in one way or another) of the "Nuclear Five" (N5), the five nuclear-weapon states recognized in accordance with the NPT: China, France, Russia, the United Kingdom (UK) and the United States (US).²

¹ Daryl G. Kimball, "The Looming Threat of Renewed U.S. Nuclear Testing", Arms Control Association, 2024, https://www.armscontrol.org/act/2024-07/focus/looming-threat-renewed-us-nuclear-testing/, accessed 11 March 2024>.

² While the official name of the format is the "P5 Process," the authors refer to the P5 as the N5 to more accurately highlight their status as the five nuclear-weapon states recognized under the NPT, emphasizing their elevated responsibility in nuclear disarmament and non-proliferation efforts.

This paper details a number of recommendations for the N5 to consider: coming up with unilateral or joint (or coordinated) statements reaffirming their commitment to the Treaty and the non-testing norm, a commitment to engagement with remaining Annex 2 States for entry into force, confidence building, monitoring and verification exercises, the provision of financial and technical resources to the International Monitoring System (IMS), and educational initiatives. The following recommendations explore various avenues that the N5 can take to strengthen and maintain the testing ban, restore at least some level of mutual trust among the N5 and more generally among the international community, and to bolster the work of the Preparatory Commission to facilitate the successful implementation of the Treaty once it has entered into force. While the authors see a value of bringing the ideas below to the attention of N5 in the first place, there should be no counter-indications regarding the active involvement of other states in their consideration.

PREVENTING A RESUMPTION OF NUCLEAR TESTING

Before the signing of the CTBT, the N5 voluntarily declared unilateral moratoria against nuclear testing. The Soviet Union, later Russian Federation, was among the first to announce its moratorium in 1990, followed by the UK in 1991, the US in 1992, and both France and China in 1996. These commitments fostered a conducive environment for negotiating the CTBT, which later embedded the norm against nuclear testing by prohibiting "any nuclear weapon test explosion or any other nuclear explosion".

However, the moratoria that the N5 have maintained since the 1990s may seem insufficient to ease the growing frustration of the international community as progress toward the CTBT's entry into force has stalled. A nuclear test by any of the N5, regardless of its intent, will not only undermine the object and purpose of the Treaty but also trigger a ripple effect, prompting other states to reconsider their commitments.

Above all, the N5 should demonstrate their enduring commitment to the CTBT by adhering to the norm against nuclear testing and reaffirming their respective moratoria. Given the current geopolitical climate, the N5 are more likely to favor unilateral statements, which can significantly lay the groundwork for joint statements. The positive impact of these statements could be amplified if made at opportune moments, such as shortly before or during the 2026 NPT Review Conference or at the 30th anniversary of the CTBT's opening for signature. In addition, the N5 could reaffirm their moratoria in conjunction with the anniversaries of their original announcement or adopt a no-first-testing pledge, promising not to be the first to conduct a nuclear test as long as other states refrain. Finally, the N5 may collaborate to reaffirm the 2016 Joint Statement on the CTBT, whereby they reiterated their commitment to "moratoria on nuclear weapons tests explosions or any other nuclear explosions pending the CTBT's entry into force".³ Taking these steps will demonstrate their dedication to the object and purpose of the CTBT and help sustain the momentum toward the Treaty's entry into force.

³ "Joint Statement on the Comprehensive Nuclear-Test-Ban Treaty by the Nuclear Nonproliferation Treaty Nuclear-Weapon States, Washington, DC, September 15, 2016", The Ministry of Foreign Affairs of the Russian Federation, 2016, https://mid.ru/en/foreign_policy/international_safety/disarmament/1534107/, accessed 11 March 2024>.

COMPLETION OF ANNEX 2 STATES' RATIFICATION FOR ENTRY INTO FORCE

The CTBT's entry into force is dependent on the ratification of the states listed in Annex 2 of the Treaty, namely the 44 members of the Conference on Disarmament on the date of 18 June 1996 and those states with nuclear research reactors, as recognized in the International Atomic Energy Agency's December 1995 edition of "Nuclear Research Reactors in the World" and 1996 edition of "Nuclear Power Reactors in the World". Of these states, those that have yet to sign and ratify are the Democratic People's Republic of Korea (DPRK), India, and Pakistan. Those who have signed and not yet ratified are China, Egypt, Iran, Israel, Russia, and the US. Notably, Russia had initially ratified the Treaty on 30 June 2000 but withdrew its ratification on 3 November 2023 due to "an imbalance between Russia and the United States..."⁴

In order to help achieve the EIF, Annex 2 States should engage with one another to build confidence in each other's willingness to comply with the Treaty. The N5 Process itself could be instrumental in any effort toward entry into force. Considering that the N5 have established their respective unilateral moratoria, ratification of the CTBT would not tangibly change the current state of affairs with regard to N5 states' nuclear testing, but may act as a step toward building increased trust among these states to be able to make progress in other facets of international security.

Obviously, the ratification by all N5 does not bring about the EIF. But given the cumulative influence of the N5, any progress on this matter among them may inspire greater trust and confidence from the remaining Annex 2 States yet to sign and ratify. If the N5 took the lead on ratification, they could then commit to engaging on a bilateral or multilateral basis and at both the high and working level with the remaining states with which they have friendly bilateral relations. This could be conducted through a range of methods, including providing security assurances, addressing regional security concerns, and conducting scientific and technological exchanges and exchanges to further enhance confidence in the non-testing norm. Even putting political pressure and confidence aside, the mere fact that all N5 have ratified the Treaty, would significantly change political and moral climate around the EIF and become a factor, that at least some of the remaining Annex 2 States would have to take into consideration in their calculations.

BUILDING CONFIDENCE AMONG THE N5 — A STRATEGY FOR CONSOLIDATING THE NON-TESTING NORM

Building trust among the N5 is key to paving the way to greater transparency while demonstrating sincere support for the Treaty and encouraging other relevant states to follow this path. By demonstrating their commitment to the CTBT through concrete initiatives and beyond political posturing, the N5 have the particular responsibility to lead the way toward the Treaty's entry into force. Initiatives to build trust among and beyond the N5 may include reducing sticking points to increase the momentum toward entry into force, enhancing confidence-building initiatives, and reinforcing the role of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) as a neutral and reliable verification actor.

⁴ "Law revoking the ratification of the Comprehensive Nuclear-Test-Ban Treaty," President of Russia, 2023, http://en.kremlin.ru/acts/news/72635/print/, accessed 11 March 2025>.

Reducing Sticking Points to Create Increase Momentum Toward Entry Into Force

Progress in nuclear disarmament and reinforcement of the non-testing norm hinges on addressing key geopolitical challenges. Reducing broader geopolitical tensions is essential to advancing the CTBT's entry into force.

Political leverage from the key N5 states on certain Annex 2 States and among certain N5 states toward accession or ratification could lead to removing major political obstacles in the consolidation of the non-testing consensus. Annex 2 States whose ratification is still needed often face domestic or regional, political and historical complexities hindering progress toward the EIF of the CTBT. Coordinated diplomatic efforts by the N5, taking advantage of unique historical relationships, can help address these obstacles by offering tailored assurances and partnership opportunities.

Enhancing N5 Confidence-Building Initiatives to Build Trust

Enhancing confidence-building initiatives among the N5 is vital for strengthening the nontesting norm and advancing the CTBT toward the EIF. Such initiatives, designed to build trust and confidence between states, could take the form of enhanced information exchange systems inspired by other instruments such as the confidence-building measures system of the Biological Weapons Convention. This system could include transparency on civil and military nuclear programs, and detailed information on testing capabilities and installations, and on national implementation measures.

In addition, other bilateral or multilateral initiatives such as peer-review exercises on multiple CTBT-related topics would further strengthen trust among the N5, and create a fertile ground for the CTBT entry into force. Beyond improving the sole leadership position of the N5 in reinforcing the non-testing norm, such initiatives create a global confidence and trust climate, encouraging broader adherence and commitment to the Treaty.

In this context, it is very important to guarantee that any confidence building initiative that one or another side may be considering, is introduced carefully – in a way that minimizes possible suspicions about intentions, hidden agendas and scoring propaganda victories.

STRENGTHENING THE INTERNATIONAL MONITORING SYSTEM

The IMS, an essential component of the CTBT's Preparatory Commission, ensures the detection of any nuclear explosion worldwide. The IMS operates through a network of seismological, hydroacoustic, infrasound, and radionuclide monitoring stations, providing data to verify compliance with the Treaty. However, as technological advancements present both new opportunities and challenges in verification, there is a growing need for enhanced financial and technical support from the N5. These states can address verification challenges by pooling resources and expertise and reducing skepticism around the Treaty's enforceability.

Leveraging Advanced Technologies for Enhanced Monitoring

Several emerging and developing technologies hold promise for bolstering IMS detection capabilities and minimizing verification challenges. One such area of innovation is detection technology. For instance, anti-neutrinos are subatomic particles emitted during the nuclear fission process which can offer direct evidence of nuclear activity. Studying the feasibility of incorporating anti-neutrino detectors⁵ into the current network could act as a complementary measure to the current radionuclide monitoring under Protocol Part I specified in the Treaty. The IMS could, therefore, address the current needs and challenges for tracking both underground and atmospheric nuclear detonations in order to identify unauthorized nuclear activities. Instead of alternating the monitoring system specified in Table 2-A of Annex 1 of the protocol, anti-neutrino detectors, like other proposed technical solutions, should be considered to augment the existing system, which provides early warnings with additional data availability without changing the current validation or detection sequence. Although still in the developmental stages due to inhibiting cost projections,⁶ anti-neutrino detectors could provide additional verification capabilities for low-yield detonations that address nuclear activities beyond traditional test explosions. In general, studies monitoring the feasibility of innovative detection technology are necessary to develop an acceptable framework for signatories regarding the future integration of other emerging detection technologies to broaden the scope of the IMS as needed.

Artificial Intelligence (AI) and Integrated Data Analysis also present transformative opportunities for the IMS. AI systems can be utilized to manage and analyze vast amounts of monitoring data, enhancing the IMS's ability to detect anomalies indicative of potential nuclear tests. Furthermore, AI-powered integrated data analysis can facilitate the creation of warning systems that focus on high-interest areas, making it easier to allocate resources efficiently and target regions with elevated monitoring needs. Machine learning algorithms can be trained to recognize complex patterns in seismic, infrasound, and radionuclide data, enabling automated alerts for anomalies. By investing in AI and integrated data solutions, the N5 can help the IMS reduce false positives, enhancing accuracy and public confidence in the monitoring system. Under extreme circumstances, trained models with reliability tested and approved can be considered as rapid-responding options of temporary arrangements specified under Article IV, section B to contain the situation and prevent further breakdown of the existing monitoring network to preserve the credibility of the IMS. However, these technologies must be carefully evaluated before being considered for installation. This could be done by a series of scientific meetings to which prominent scientists and designers should be invited.

Preparing for Setbacks to CTBT Progress

The CTBT faces growing risks, including the possible retraction of the nuclear testing moratoria, necessitating proactive measures to protect the IMS and the Treaty as a whole. One critical area for N5 investment is funding studies on the resilience of the IMS under adverse scenarios, such as funding shortages or simultaneous nuclear tests. These studies would prioritize identifying key IMS components — such as seismic and radionuclide stations and central data analysis facilities — that are indispensable for maintaining basic operational capabilities. Developing contingency plans, including mobile monitoring units and prepositioned replacement equipment, could ensure the survival of core systems. Additionally, optimizing station operations during resource constraints and strengthening rapid recovery mechanisms would help minimize disruptions and maintain credibility in the event of crisis conditions.

⁵ Bernstein, Adam, Todd West, and Vipin Gupta, "An Assessment of Antineutrino Detection as a Tool for Monitoring Nuclear Explosions", Science & Global Security 9 (3): 235–55, 2001, https://doi.org/10.1080/08929880108426496, accessed 11 March 2025>.

⁶ Michael Foxe, Theodore Bowyer, Rachel Carr, John Orrell, and Brent VanDevender, "Antineutrino Detectors Remain Impractical for Nuclear Explosion Monitoring", Pure and Applied Geophysics 178 (3): 2753–2763, 2021, <https://doi.org/10.1007/s00024-020-02464-6/, accessed 11 March 2025>.

The feasibility of cooperation between the IMS and other international monitoring systems should also be explored to protect it from dissolution in worst-case scenarios. By aligning the IMS's capabilities with global needs—such as earthquake and tsunami monitoring, environmental tracking, or disaster response—it can broaden its utility and, more importantly, consolidate its role in global affairs. Collaborative frameworks would not only demonstrate the IMS's multifunctional value but also enhance its integration into the global monitoring ecosystem, making its continued operation indispensable even if direct CTBT support is diminished. Such efforts would ensure the IMS's resilience, maintain its contributions to global security, and preserve the integrity of international non-proliferation efforts.

Unifying Technological Standards for Seamless Cooperation

A critical step toward enhanced IMS performance involves strengthening joint mechanisms to unify technological standards across N5 member contributions. As new technologies are integrated into the IMS, varying national approaches could create compatibility issues. By developing unified standards, the N5 can ensure that all IMS components—whether seismological, radionuclide, or data analysis systems—operate cohesively, making data sharing and analysis more efficient. Establishing these standards would also simplify future upgrades and foster smoother collaboration among technical staff from different countries (e.g., cooperative exercises under a more permissible international environment), reinforcing the IMS's long-term effectiveness by improving the readiness of the CTBTO Provisional Technical Secretariat while preparing for entry into force.

EDUCATION INITIATIVES ON THE CTBT AND THE N5

Through collaborative educational initiatives, the N5 can substantially strengthen the standing of the CTBT, helping to address concerns about verification, regional security issues, and the lack of universal ratification. By promoting the benefits of the CTBT, its verification systems, and nuclear non-proliferation goals, the N5 can make significant contributions to the Treaty's success. These initiatives will not only consolidate the CTBT but also reinforce the global nuclear disarmament and non-proliferation regime, underscoring the N5's leadership role in these areas.

Joint Educational and Public Diplomacy Initiatives

The N5 should initiate a series of educational and public diplomacy efforts to enhance global awareness of the CTBT's importance and its verification mechanisms. These efforts may include participation in international forums, and the creation of public informational resources. Key milestones, such as CTBT anniversaries and the upcoming NPT 11th Review Conference, present ideal opportunities for impactful public education initiatives.

Scientific Conferences and Workshops on IMS and CTBT Verification

The N5 could hold regular scientific workshops and conferences on CTBT verification, covering topics such as IMS sensor functions, data collection, and data analysis. These events, involving scientists, technicians, and policymakers, would help deepen understanding of monitoring technologies and showcase the technical feasibility of CTBT objectives while highlighting advancements in IMS capabilities.

Capacity Building and Training for Non-Signatory States

To foster broader support for the CTBT, the N5 should engage in capacity-building initiatives targeted at non-signatory states, including technical assistance, training, and infrastructure support for establishing National Data Centers and integrating IMS monitoring. The next on-

site inspection Integrated Field Exercise⁷ will further bolster these projects, deepening the application of CTBT verification measures and promoting a culture of transparency and trust. Additionally, trained experts within these countries could become international advocates for the Treaty, supporting its universalization.

Youth Engagement and Support for Civil Society in Disarmament Education

Engaging younger generations is essential for maintaining long-term support for the CTBT. The N5 could fund youth-focused programs, such as internships, competitions, and Model United Nations activities centered on nuclear disarmament, cultivating future leadership in this field. Moreover, partnerships with civil society organizations, NGOs, and educational institutions could help integrate CTBT-related educational materials into school and university curricula, thereby promoting a broad understanding of nuclear disarmament issues.

CONCLUSION

The CTBT represents a cornerstone of the global non-proliferation and disarmament regime, but its entry into force remains challenging. The N5 must reaffirm their collective commitment through strategic initiatives such as joint, unilateral or coordinated statements during key milestones like the 2026 NPT Review Conference or CTBT-related anniversaries or no-first-testing pledges. These actions, complemented by trust-building measures such as transparency on nuclear programs, peer reviews, and enhanced information exchange mechanisms, will help create a conducive environment for ratification by Annex 2 States. Demonstrating unified leadership through such efforts will bolster confidence in the CTBT's framework and its objectives.

A key focus must also be on strengthening the IMS. The N5 should address vulnerabilities by funding resilience measures, including studies on operational continuity during funding shortages or simultaneous nuclear tests. Expanding the role of the CTBTO to include enhanced transparency measures and impartial inspections could bolster trust among states while preventing the expansion of testing sites or infrastructure, which would help preserve the non-testing norm. Integrating advanced monitoring technologies, such as artificial intelligence and anti-neutrino detection, alongside cooperative red-team exercises to refine detection methods will enhance IMS accuracy, reliability, and credibility in the global verification regime.

Finally, public diplomacy and education initiatives are essential to amplifying these technical and policy advancements. The N5 must engage in targeted outreach, leveraging workshops, scientific exchanges, and capacity-building programs to underscore the importance of CTBT. Collaborating with states to provide technical training and infrastructure support will foster trust and demonstrate the Treaty's broader benefits. By combining transparent leadership, robust technical enhancements, and sustained educational efforts, the N5 can strengthen the CTBT's framework, ensuring its relevance and efficacy in safeguarding international security for future generations.

⁷ The next Integrated Field Exercise (IFE), following those in Kazakhstan (2008) and Jordan (2014), was initially expected to be held in 2025 in Sri Lanka. However, the Government of Sri Lanka has informed that the country is not in a position to host the CTBTO IFE. The location and date of the next IFE have not been determined yet. For more details: "Sri Lanka regrets not hosting Nuclear Test Ban Treaty field event", EconomyNext, 2025, https://economynext.com/sri-lanka-regrets-not-hosting-nuclear-test-ban-treaty-field-event-206676, accessed 11 March 2025.

Lessons Learned from the Ratification of the CTBT: Indonesia

Bayu Wicaksono Shasta Kirana Arianto

ABSTRACT

Indonesia's ratification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) in 2012 the most recent among Annex 2 States to do so — underscores its role in advancing the treaty's entry into force. Yet the CTBT's entry into force (EIF) remains uncertain due to the requirement that, for the EIF to happen, all Annex 2 States must ratify the treaty. This article examines Indonesia's journey towards ratification, emphasising its historical, political, and strategic dimensions, including the factors that prolonged the process. The CTBT ratification process, spanning 15 years, involved overcoming domestic political shifts, expertise-related constraints, and evolution of governmental priorities, associated with changes at the top level of the government. Despite initial aspirations for the acquisition of nuclear weapons in the 1960s, domestic and geopolitical factors led Indonesia to prioritise nuclear non-proliferation and disarmament, alongside the promotion of peaceful uses of nuclear technology. This process highlights the interplay between security landscape and leadership in addressing nuclear-related issues which lead to Indonesia's decision to ratify the CTBT. Following the ratification of the Treaty, Indonesia has hosted six seismic stations and leveraged technical collaboration with the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO), contributing to the global verification system and supporting civilian nuclear activities. Moreover, Indonesia's ratification is expected to bolster the country's position within the broader nuclear non-proliferation regime, including regional mechanisms such as the Southeast Asia Nuclear-Weapon-Free Zone (SEANWFZ). Nevertheless, tangible progress remains constrained, particularly in securing the ratification of all Annex 2 states and in enhancing Indonesia's role within the broader nuclear non-proliferation and disarmament framework. The reluctance of some leading Nuclear-Weapon States (NWS) to ratify the CTBT, coupled with current geopolitical dynamics and the growing fragmentation of the international system—which hamper broad multilateral efforts to foster mutual trust—poses significant challenges for Indonesia in its disarmament and non-proliferation advocacy, as well as in achieving the overarching goal of the CTBT's entry into force.

INTRODUCTION

As part of the non-proliferation regime, the Comprehensive Nuclear-Test-Ban Treaty (CTBT) plays a pivotal role in preventing nuclear test explosions. Opened for signature in 1996, the CTBT has been signed by 187 states and ratified by 178. However, the treaty has not yet entered into force due to the fact that nine countries from among those listed in Annex 2 (states whose ratification is the condition for the EIF) have not ratified it so far: China, the Democratic People's Republic of Korea (DPRK), India, Iran, Pakistan, Egypt, Israel, Russia, and the United States of America (U.S.).

Thus, the long process towards the entry into force of the CTBT, which started almost 30 years ago (in 1996) is far from being completed. The story of Indonesian ratification may shed some light on the difficulties and slow pace of this process, although it is worth noting that there is no one-size-fits-all explanation for all the difficulties standing in the way toward the

ratification by relevant countries. During the CTBT's negotiation between 1994 and 1996 at the Conference on Disarmament, Indonesia, was guided by the necessity of a comprehensive, just, and realistic nuclear test ban as a critical step towards global disarmament.¹ Following its ratification on 6 February 2012— almost 16 years after signing the Treaty on 24 September 1996, Indonesia has emerged as an advocate, urging other Annex 2 States to ratify the treaty.

In addressing nuclear non-proliferation and disarmament goals, it is important to see the strategic role of nuclear weapons which cannot be disentangled from security dynamics. NWS are often believed to possess distinct advantage by relying on nuclear weapons in the pursuit of their national or security agendas. This is not to say that they are ready to use such weapons on any occasion or are happy to exist in an unconstrained nuclear anarchy. Instead, they rely on an implicit threat of using NWs which is often described by a popular term of "deterrence". This leads to a continuous rebuilding, modernisation and diversification of their nuclear arsenals. On the other hand, Non-Nuclear-Weapon States (NNWS), like Indonesia, navigate their national interests by exploring less aggressive pathways to safeguard their strategic priorities. This highlights the dilemma surrounding weaponisation of nuclear science. While some may argue that pursuing nuclear capabilities serves to safeguard national interests, the reality is that possessing nuclear arsenals can provoke multi-domain arms races and erode trust among actors which can lead to a much more dangerous international environment. In light of this, George Shultz, William Perry, Henry Kissinger, and Sam Nunn highlighted in 2007 that the accelerating proliferation of nuclear weapons and the diminishing effectiveness of nuclear deterrence heightened the risk of the "deadliest weapons ever invented" falling into dangerous hands, underscoring the urgent need to "reassert the vision" of a nuclear weapons-free world.² Furthermore, some state actors are now may leverage nuclear nonproliferation agenda to present themselves as peaceful nations, distancing themselves from the perception of wielding power irresponsibly to influence others.

In following Indonesia's position on the issue of nuclear non-proliferation and CTBT ratification, it is important to take a look at its historical trajectory, particularly Indonesia's emergence as a newly independent state in 1949 in the post-Second World War era. The decolonisation process and the Cold War rivalry among major powers presented a dilemma for states like Indonesia, giving rise to various thoughts about using nuclear technology proliferation to bolster country's international influence. Since declaring independence on 17 August 1945, Indonesia has navigated a complex geopolitical landscape shaped by decolonisation, the Cold War, and more specific challenges of regional, economic and cultural nature. As a strategically located medium-size country with rapidly growing population, yet facing resource constraints, it had to consider a range of strategically important decisions about its place in the world, geopolitical orientation and military capabilities.

INDONESIA'S FOREIGN POLICY TOWARDS PROHIBITION OF NUCLEAR TESTING

Nuclear non-proliferation, nuclear disarmament and nuclear testing issues in the context of evolving national security environment of Indonesia (early years after independence 1945-1967, during President Soekarno's era).

¹ Rebecca Johnson, "Unfinished Business: The Negotiation of the CTBT and the End of Nuclear Testing", United Nations Institute for Disarmament Research, 2009, <https://unidir.org/files/publication/pdfs/unfinished-business-the-negotiation-of-the-ctbt-and-the-end-of-nuclear-testing-346.pdf/, accessed 11 March 2025>.

² George Shultz, William Perry, Henry Kissinger, and Sam Nunn, "A World Free of Nuclear Weapons", Wall Street Journal, 2007, https://media.nti.org/pdfs/NSP_op-eds_final_.pdf/, accessed 11 March 2025>.

Since its independence in 1945, Indonesia has adopted a "free and active" foreign policy. The policy is most recently explained in Indonesia's Law No. 37 of 1999 on Foreign Relations. As articulated in the fourth paragraph of its Preamble, the "free and active" foreign policy enables Indonesia to freely determine its stance and policies on international issues without binding itself a priori to any global power, while actively contributing, both intellectually and through participation, to the resolution of global conflicts, disputes, and challenges, with the overarching aim of promoting a world order founded on independence, lasting peace, and social justice.³ Firstly announced in June 1958, Indonesia's stance against the atomic and hydrogen bombs was also reaffirmed by Foreign Minister Soebandrio.⁴ This initial stance against nuclear weapons has brought to the cooperation with the U.S. in developing a 50-kilowatt nuclear research reactor TRIGA-Mark II under a five-year bilateral agreement in the framework of the Atoms for Peace Program.⁵ To advance its nuclear capabilities in preparing its scientists, Indonesia in 1958 established the Institute of Atomic Energy, or Lembaga Tenaga Atom (LTA), which later became the Nuclear Energy Regulatory Agency (BATAN).

Following national security dynamics and considerations, later in the 1960s, the idea of acquiring nuclear weapons was briefly considered. Government officials began publicly expressing their intent to acquire a nuclear bomb shortly after China conducted its first nuclear test in October 1964. In a presidential decree on atomic energy issued on 26 November 1964, President Soekarno emphasised that resources required for producing atomic energy and nuclear fuel were "essential for the people and the nation in completing the national revolution" and, therefore, should be "owned and mastered by the nation".⁶ Inspired partially by China's nuclear test, Indonesian leaders began envisioning the possibility of joining the nuclear club. Speaking at a Muslim Congress in Bandung on 24 July 1965, Soekarno proclaimed, that "God willing, Indonesia will shortly produce its own atom bomb," framing it as an instrument to protect national sovereignty in Indonesia's broader revolutionary struggle against Western powers, while explicitly rejecting its use for aggression.⁷ Parliamentary Speaker Arudji Kartawinata expressed confidence that such an achievement would be welcomed by the Indonesian people. He was followed by Minister Soebandrio, who had previously disavowed nuclear ambitions, but later endorsed the concept, stating, "We have no objections to all nations and countries in the world possessing atomic and nuclear weapons".⁸ During this era, Indonesia lacked the domestic capacity to conduct its own nuclear research and develop nuclear weapons independently, which necessitated potential support from an established nuclear state. Considering the geopolitical conditions at this period, China's recent success in nuclear weapons testing emerged as a promising

³ "Undang-Undang Republik Indonesia Nomor 37 Tahun 1999 Tentang Hubungan Luar Negeri Dan Terjemahan Tidak Resmi Dalam Bahasa Inggris", Database Peraturan, 1999, <https://peraturan.bpk.go.id/Details/45358/uu-no-37-tahun-1999/, accessed 11 March 2025>.

⁴ Arsip Nasional RI, "Pada 12 Juni 1958, Presiden Sukarno berpidato di Istana Negara saat rapat umum menentang bom atom dan hydrogen...", X, 2023, <https://x.com/ArsipNasionalRI/status/1668217161079476225/, accessed 11 March 2025>.

⁵ Alda Anindea, "Indonesia's Evolving Nuclear Policy: The Trajectory of a Disarmament Champion", Fondation pour la Recherche Stratégique, 2024, https://www.frstrategie.org/sites/default/files/documents/publications/ recherches-et-documents/2024/072024.pdf/, accessed 11 March 2025>.

⁶ Robert M. Cornejo, "When Sukarno sought the bomb: Indonesian nuclear aspirations in the mid-1960s", The Nonproliferation Review, 7 (2): 31–43, 2000, <https://doi.org/10.1080/10736700008436808/, accessed 11 March 2025>.

⁷ Ibid.

⁸ Ibid.
factor in strengthening the Jakarta-Peking axis approach for collaboration in nuclear weapons development. Securing the necessary resources, technology, and international cooperation posed significant challenges. In fact, Indonesia's domestic political and financial constraints, compounded by the renowned political shifts in 1965, diverted its attention from nuclear ambitions. Consequently, programmes aimed at developing nuclear weapons were no longer prioritised.

Nuclear Policy under the Era of President Soeharto (1967 – 1998)

The transition of power to President Soeharto marked another shift in Indonesia's nuclear policy. The period from 1967 to 1998 was characterised by distinct geopolitical dynamics, differing from those of Indonesia's struggle for independence. This era saw the establishment of closer relations with the West, in political, economic and socio-cultural aspects. These strengthened ties were considered one of the key outcomes of the U.S. containment policy in Southeast Asia, aimed at curbing further communist expansion. In the realm of nuclear non-proliferation and disarmament, Cold War tensions brought the world closer to nuclear catastrophe and facilitated the wider proliferation of nuclear weapons. However, this period also witnessed notable progress in the non-proliferation regime, including, among others, the Strategic Arms Limitation Talks (SALT I and II), the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), and the talks aimed at ending nuclear testing.

Under President Soeharto, Indonesia prioritised economic development and conventional military capabilities over the consideration of acquiring nuclear weapons. This set of national policies strengthened Indonesia's image as a peaceful nation committed to a "free and active" foreign policy and promoting global nuclear disarmament, as substantial financial and institutional costs associated with nuclear weapons were re-allocated to other priorities. These changes underscored the changing national security perception, security landscape and futility of nuclear conflict, highlighting that such wars could never be won and were not worth fighting.

From the interview with Arbie Bakrie, former Head of the Nuclear Reactor Center at Puspiptek Serpong and former Deputy Head of the Nuclear Energy Regulatory Agency (BATAN) until 2002, it follows that during President Soeharto's administration, when he first joined BATAN as a reactor operator, nuclear research on peaceful purposes was far from neglected.⁹ On the contrary, it was regarded as one of the country's key research priorities, on par with aeronautics and aviation. Soeharto's administration placed Indonesia's nuclear activities under the safeguards of the International Atomic Energy Agency (IAEA), following Indonesia's signature of the NPT in 1970, which it ratified in 1979. In the national instrument of NPT ratification (Undang-Undang No. 8 Tahun 1978), Indonesia acknowledged that the possession of nuclear weapons does not guarantee enhanced national security and, instead, risks escalating tensions between states.¹⁰ Indonesia demonstrated its commitment to the NPT by adhering to all its provisions, and ratifying both the IAEA Comprehensive Safeguards Agreement and the Additional Protocol.¹¹ Further advancing nuclear non-proliferation,

⁹ Dr. Arbie Bakrie, interview by author, Jakarta, 8 December 2024.

¹⁰ "Undang-Undang Nomor 8 Tahun 1978 tentang Pengesahan Perjanjian Mengenai Pencegahan Penyebaran Senjata Senjata Nuklir", Jaringan Dokumentasi dan Informasi Hukum Nasional, 1978, <https://jdih.bapeten.go.id/unggah/dokumen/peraturan/3-full(diubah).pdf/, accessed 11 March 2025>.

 [&]quot;Indonesia Tekankan Hak Kembangkan Energi Nuklir", Kementerian Sekretariat Negara Republik Indonesia,
 2008, https://setneg.go.id/baca/index/indonesia_tekankan_hak_kembangkan_energi_nuklir/, accessed 11
 March 2025>.

Indonesia actively supported the Southeast Asia Nuclear Weapon-Free Zone (SEANWFZ) Treaty, signed in Bangkok on 15 December 1995. This policy was built on earlier discussions surrounding the Zone of Peace, Freedom, and Neutrality (ZOPFAN) declaration in the 1970s. ZOPFAN emphasised peaceful dispute resolution, non-interference in member states' internal affairs, and the rejection of domination or hegemony. This marked a clear trajectory towards Indonesia's commitment in promoting non-proliferation and the peaceful use of nuclear energy. In addition, Indonesia has consistently demonstrated its openness by engaging with the international community and showcasing its peaceful nuclear programme — proving that there was nothing to conceal.¹²

While security dynamics have evolved since the early years of Indonesia's independence, President Soeharto continued to focus national resources on technological research in nuclear development. However, it is unsurprising that during this period, external actors remained cautious, a sentiment further reinforced by Indonesia's abundant natural resources, which could potentially be used as a source of nuclear fuel. Adding to this, Indonesia is a nation with the technology, expertise, and infrastructure to develop nuclear weapons, yet opting not to pursue them. While Indonesia continues its nuclear cooperation with countries such as Germany, the Russian Federation, and the U.S., these partnerships have been limited in scope. Yet, within this constrained framework, a significant achievement in Indonesia's nuclear programme was the Kartini Research Reactor in Yogyakarta, inaugurated in 1979. It served as a symbol of Indonesia's growing independence and the increasing capability of its human resources.¹³ This milestone is particularly notable for domestic scientists, especially when compared to the two earlier reactors, and demonstrates the country's ability to develop a peaceful nuclear research reactor despite complex political challenges.

Path Towards Indonesia's Ratification of the CTBT (Post reformation era, 1998 – Present)

The legacy of nuclear programmes under the Soeharto presidency resulted in the development of nuclear technology in Indonesia – including efforts to raise public awareness of the technology. This has improved the availability of expertise in nuclear-related fields, both among scientists and decision-makers in the government. Considering that the ratification of CTBT is the responsibility of the legislature, the House of Representatives of the Republic of Indonesia (DPR RI) played a crucial role in making the CTBT a national priority in the preparation of a national law on the ratification. Members of DPR RI, who came from diverse backgrounds and who initially were not necessarily familiar with details, were tasked with this responsibility. Between 1996 and the late 1990s, little progress was made. The absence of experts on nuclear non-proliferation issues meant that setting an agenda for CTBT ratification became less attractive and political commitment in addressing this issue was not seen as a priority.

Furthermore, in 1998, Indonesia's domestic politics were thrown into turmoil. The Asian financial crisis destabilised the political landscape, leading to Soeharto's ousting and ushering in a new era of reform. In the early 2000s, Indonesia focused on democratisation, improving governance, economic restructuring, poverty alleviation, and peacebuilding efforts, particularly in Aceh. Competing priorities during this period of political reform contributed to the delay in ratifying the CTBT. In addition, one of the outcomes of the political reform was the enactment of the Law of the Republic of Indonesia Number 24 of 2000 on International

¹² Dr. Arbie Bakrie, interview by author, Jakarta, 8 December 2024.

Agreements, which introduced a more detailed framework for the ratification or approval of international treaties under DPR RI.¹⁴ Under the Presidency of Susilo Bambang Yudhoyono in 2004-2014, Indonesia achieved greater domestic stability, providing an opportunity to reengage with the international community including on CTBT-related issues. In multilateral platforms, Indonesia has played an active role, notably by chairing the NAM Working Group on Disarmament in 2009.¹⁵

Later, in 2010, came a significant point of CTBT's ratification process, when Former Minister of Foreign Affairs R.M. Marty Natalegawa announced Indonesia's intention to ratify the Treaty.¹⁶ I Gusti Agung Wesaka Puja, Executive Director of ASEAN-IPR and former Ambassador of Indonesia to Austria, Slovenia, and Permanent Representative to International Organisations in Vienna, highlights the strong commitment of former Minister of Foreign Affairs, R.M. Marty Natalegawa in prioritising disarmament and non-proliferation, including the ratification of the CTBT, within Indonesia's foreign policy agenda.¹⁷ In the post-reformation era, both the global and domestic environments reached a juncture in which Indonesia could prioritise the ratification of CTBT. The Ministry of Foreign Affairs assumed a central role in this context. The Ministry also bears the burden of coordinating with other ministries and bureaucratic entities – a process that is often lengthy and time-consuming.

According to former Minister of Foreign Affairs, R.M. Marty Natalegawa, it is explained further about the situation of CTBT ratification that Indonesia moved away from its earlier stance, which conditioned its CTBT ratification on prior P5 ratifications, towards an approach of "leading by example" to reshape the dynamics of nuclear non-proliferation and disarmament.¹⁸ Thus, effective leadership became indispensable in showcasing Indonesia's commitment and capacity to influence the global nuclear non-proliferation and disarmament agenda.

It is also important to take a look back to 2009, when the initial intention for Indonesia was to ratify the CTBT immediately after the U.S.¹⁹ During the year, U.S. President Barack Obama had affirmed his administration's readiness to seek an urgent ratification of the CTBT, however, there were oppositions and domestic debates that hindered the U.S.' decision to ratify the treaty.²⁰

visits-ctbto-preparation, accessed 11 March 2025>.

¹⁴ "Undang-Undang Nomor 24 Tahun 2000 tentang Perjanjian Internasional", Presiden Republik Indonesia, 2000, <https://jdih.setkab.go.id/PUUdoc/7226/uu0242000.pdf, accessed 11 March 2025>.

¹⁵ "Letter Dated 25 August 2009 from the Permanent Representative of Egypt Addressed to the President of the Conference on Disarmament Transmitting the Paragraphs of the Introduction and Section on Disarmament and International Security of the Final Document of the XV Summit of Heads of State and Government of the Non-Aligned Movement Held in Sharm El Sheikh, Egypt From 11 To 16 July 2009", United Nations Official Document System, 2009, https://documents.un.org/doc/undoc/gen/g09/634/98/pdf/g0963498.pdf, accessed 11 March 2025>.
¹⁶ "Large Indonesian parliamentary delegation visits CTBTO in preparation for ratification", CTBTO Preparatory Commission, 2011, https://www.ctbto.org/news-and-events/news/large-indonesian-parliamentary-delegation-

¹⁷ I Gusti Agung Wesaka Puja, interview by author, Jakarta, 26 November 2024.

¹⁸ Dr. R.M. Marty Natalegawa, interview by author, Online, 14 January 2024.

¹⁹ "Indonesia will ratify nuclear test ban immediately following U.S. ratification", Carnegie Endowment for International Peace, 2009, <https://carnegieendowment.org/posts/2009/06/indonesia-will-ratify-nuclear-testban-immediately-following-us-ratification?lang=en/, accessed 11 March 2025>.

²⁰ "Some Considerations Regarding the Ratification of the CTBT by the United States", Carnegie Endowment for International Peace, 2009, <https://carnegieendowment.org/research/2009/07/some-considerations-regardingthe-ratification-of-the-ctbt-by-the-united-states?lang=en/, accessed 11 March 2025>.

The Ministry of Foreign Affairs provided the DPR RI with the necessary academic studies to support this process. During this period, a bill for ratification was submitted to DPR RI, supported by extensive consultations, including parliamentary visits to the CTBTO in Vienna. This marked a shift in Indonesia's position as the country moved forward with ratification. Before ratifying the CTBT, a delegation from Commission I of DPR RI, a commission responsible in defence, foreign and information affairs, visited the Preparatory Commission for the CTBTO to observe its activities and meet with Executive Secretary Tibor Tóth. During the visit, the delegation presented the following key points regarding Indonesia's draft law on CTBT ratification:²¹

1. Ratification should reflect Indonesia's responsible leadership in advancing global nuclear non-proliferation and disarmament.

2. A senior Indonesian diplomat should be appointed as a special envoy to promote Indonesia's stance on CTBT ratification in Southeast Asia.

2. The Indonesian Parliament should lead efforts to encourage CTBT ratification among regional parliaments.

4. Indonesia seeks to increase its contributions to and ownership within the CTBTO.

5. Collaboration on operating and maintaining Indonesia's six certified seismic stations will continue.

6. CTBT ratification should facilitate ASEAN-CTBTO collaboration, particularly within the SEANWFZ.

7. Indonesia will enhance its nuclear security legal framework with CTBTO, IAEA, and other international support.

On 6 February 2012, Natalegawa personally submitted Indonesia's CTBT ratification instrument to UN Secretary-General Ban Ki-moon at a special ceremony in New York.²² In addition to its own CTBT ratification, Indonesia has been consistently urging NWSs to ratify the treaty.²³

Implications of CTBT Ratification for Indonesia

For Indonesia, the ratification of the CTBT plays a significant role in capacity building, impacting various levels from policymakers and decision-makers to those engaged at the technical level within the International Monitoring System (IMS) and the International Data Centre (IDC). On a technical level, the Meteorology, Climatology, and Geophysical Agency (BMKG) is the designated institution tasked with fulfilling Indonesia's obligations under the treaty, including providing and processing data necessary for monitoring the absence of nuclear tests.

As part of the IMS, Indonesia hosts six fully operational seismic stations (Lembang, Jayapura, Sorong, Parapat, Kappang, Baumata). Prior to CTBT ratification, Indonesia has signed a

²¹ "Report on the Working Visit of Commission I of the Indonesian House of Representatives to Austria", The House of Representatives of the Republic of Indonesia, 2011, https://berkas.dpr.go.id/akd/dokumen/K6-12-f82a82ab5877d9d3bc9fe4bf09041a3c.pdf/, accessed 11 March 2025>.

²² "CTBT brought closer to entry into force by Indonesia's ratification", CTBTO Preparatory Commission, 2012, <https://www.ctbto.org/news-and-events/news/ctbt-brought-closer-entry-force-indonesias-ratification/, accessed 11 March 2025>.

²³ "Disarmament and Non-proliferation of Weapons of Mass Destruction", Ministry of Foreign Affairs of the Republic of Indonesia, https://suva.kemlu.go.id/portal/id/read/90/halaman_list_lainnya/perlucutan-senjatadan-non-proliferasi-senjata-pemusnah-massal/, accessed 11 March 2025>.

Tsunami Warning Arrangement in 2008 with the Preparatory Commission for the CTBTO, which aids in enhancing the country's tsunami early warning systems. The IMS network, along with the communication infrastructure connected to the IDC, enhances the technical capacity and capability of local human resources to operate in accordance with relevant IMS protocols. These protocols not only encompass the operation of IMS stations but also entail a comprehensive understanding of the complexities of the IMS.

Furthermore, Indonesia's ratification of the CTBT enhances its diplomatic standing, demonstrating its leadership in advancing nuclear non-proliferation efforts. As one of the largest countries in Southeast Asia, both in terms of population and territory, Indonesia's ratification of the CTBT sends a strong message to other nations, encouraging wider adherence to nuclear non-proliferation regime.

Continuing the commitment to CTBT, on 19–20 May 2014, Indonesia hosted a conference in Jakarta, supported by the European Union (EU) and the Government of Japan, to promote the ratification of the CTBT in Southeast Asia, the Pacific, and the Far East.²⁴ The conference, officiated by former Minister of Foreign Affairs, R.M. Marty Natalegawa and CTBTO Executive Secretary Lassina Zerbo, brought together representatives from 18 countries in the region to discuss advancing the nuclear test ban. In September 2023, during the High-Level Plenary Meeting to Commemorate and Promote the International Day for the Total Elimination of Nuclear Weapons at the UN Headquarters in New York, the continuing tenure of Minister of Foreign Affairs Retno L.P. Marsudi attended the delivery of both the ASEAN Joint Statement and the Indonesian Government Statement. These demanded that all nations must adhere to and fulfil their obligations under various international treaties, including the NPT, CTBT and TPNW.²⁵ The statement underscored the importance of strong political will to uphold the credibility and integrity of these treaties.

Current Challenges to the CTBT and Indonesia's Continuing Role in Preventing Nuclear Testing

Indonesia's strategic position, nestled between the Indian and Pacific Oceans, offers a unique advantage in advancing the CTBT by extending its jurisdiction over its vast territory and large population. A vast territory, expanded territorial jurisdiction, and a large population provide an additional weight to Indonesia`s efforts in the field of ending nuclear testing an in a wider area of nuclear disarmament. However, the path to the universalisation of the CTBT faces significant challenges, particularly due to the non-ratification of the treaty by several key Annex 2 States. These NWS, whose nuclear capabilities are seen as cornerstones of their security, require trust-building efforts for a comprehensive approach to disarmament.²⁶ The recent de-ratification of the CTBT by the Russian Federation, driven by evolving geopolitical tensions, highlights the difficulty in persuading these NWS to relinquish their nuclear programmes, arsenals, including their motives to conduct further nuclear testing.

²⁴ "Indonesia hosts two-day regional conference on the CTBT", CTBTO Preparatory Commission, 2014, <https:// www.ctbto.org/news-and-events/news/indonesia-hosts-two-day-regional-conference-ctbt/, accessed 11 March 2025>.

²⁵ "Indonesia Calls for Nuclear Weapons Total Elimination", Cabinet Secretariat of the Republic of Indonesia, 2023, <https://setkab.go.id/en/indonesia-calls-for-nuclear-weapons-total-elimination/, accessed 11 March 2025>.

²⁶ Mitsuru Kurosawa, "The US Initiative on Creating an Environment for Nuclear Disarmament", Journal for Peace and Nuclear Disarmament 3 (2): 283–298, 2020, <https://doi.org/10.1080/25751654.2020.1834802/, accessed 11 March 2025>.

In the context of trust amongst actors, the contemporary rise in new forms of military alliances involving various combinations of nuclear and non-nuclear weapon states—such as AUKUS—poses a new challenge to broad multilateral efforts in addressing nuclear nonproliferation and disarmament in addition to the already complicated geopolitical dynamics. While multilateralism emphasises inclusivity, minilateralism is perceived as a tool for more powerful states to bypass the slower, consensus-driven processes of broader multilateral forums.²⁷ In Southeast Asia, this trend carries risks tied to the strategic agendas of major powers that establish and steer such mechanisms to serve their own geopolitical and geoeconomic interests.²⁸ These smaller, exclusive security arrangements can undermine trust among states and detract from broader, more inclusive frameworks, such as the CTBT, preventing inclusive approach that could help trust building amongst the remaining Annex 2 States. The reliance on minilateral cooperation often leads to a prioritisation of exclusive interests over global collective security, further complicating efforts to achieve a unified stance on nuclear non-proliferation and disarmament goals. It may also heighten the risk of nuclear technology being pursued for military purposes. For these reasons, Indonesia is concerned about the AUKUS project, which involves the acquisition of sensitive nuclear know-how, the use of HEU as submarine propulsion fuel by a NNWS.

CONCLUSION

Indonesia's long journey towards ratifying the CTBT provides valuable insights, emphasising that there is no one-size-fits-all solution, as each state or region faces unique domestic and international security challenges.

Firstly, the security landscape shapes the environment influencing decision-makers' behaviour regarding nuclear policy. Examining Indonesia's security landscape is central to understanding the motives behind its nuclear policy—whether these are peaceful or not. Such motives were evident in the early years of Indonesia's independence under President Soekarno, when nuclear weapons option was briefly considered but later abandoned during President Soeharto's tenure. It was only in the post-reformation era under President Susilo Bambang Yudhoyono, when Indonesia achieved greater economic and political stability alongside a more conducive security landscape, that CTBT ratification was revisited and properly prioritised. As the security landscape continues to evolve, Indonesia's ability to navigate its complex geopolitical environment while balancing domestic priorities and international expectations.

Secondly, consistent advocacy and leadership by decision-makers have been crucial in aligning national interests with global objectives. Indonesia's CTBT ratification could have taken a different trajectory without leadership to challenge the status quo. This leadership role must also be supported by a conducive political environment, where resources and support are strategically allocated. Indonesia's policy shift from demanding that NWS should ratify the CTBT first to unilaterally ratifying the treaty marked a significant change influenced by this leadership.

²⁷ Megan Dee, "Minilateralism and Effective Multilateralism in the Global Nuclear Order", Contemporary Security Policy, 45 (3): 494–524, 2024, <https://doi.org/10.1080/13523260.2024.2373658/, accessed 11 March 2025>.

²⁸ Bhubhindar Singh and Sarah Teo, "Minilateralism in the Indo-Pacific: The Quadrilateral Security Dialogue, Lancang-Mekong Cooperation Mechanism, and ASEAN", Abingdon, Oxon: Routledge, 2020.

Nevertheless, challenges to CTBT universalisation remain significant, as the treaty's impact is limited without the ratification of all Annex 2 States.

Indonesia's strategic position in Southeast Asia offers a unique advantage in advocating for the CTBT's relevance and broader ratification. Its leadership within ASEAN, particularly in promoting frameworks such as the SEANWFZ, which includes urging NWS to ratify its Protocol, demonstrates Indonesia's commitment to the nuclear non-proliferation regime. As Indonesia continues to navigate these challenges, its experience highlights the importance of trust-building measures, inclusive dialogue, and sustained advocacy to address the concerns of both NWS and NNWS.

In conclusion, the CTBT remains a cornerstone of global efforts to permanently outlaw nuclear testing, banning explosions in all environments—above ground, underwater, and underground. Since its opening for signature in 1996, the treaty's norms have significantly curtailed testing, with only 10 occurrences compared to over 2,000 in the preceding five decades, and in this century, only the DPRK has breached the emerging non-testing norm, underscoring the treaty's impact and the importance of its universal adoption. Further research into the ratification processes of other actors could uncover unique experiences, further reinforcing the norm and advancing nuclear non-proliferation and disarmament.

CTBT Non-Ratifying Non-Annex 2 States: What are the Reasons for Delay? Examples of Nepal, Somalia and Yemen

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ABSTRACT

The Comprehensive Nuclear-Test-Ban Treaty (CTBT), established to prohibit all nuclear test explosions, stands as a pivotal framework in the global disarmament and non-proliferation regime. However, while the treaty has earned considerable support internationally, three Signatory Non-Annex 2 States – Nepal, Somalia, and Yemen – have yet to ratify it, raising questions about the underlying reasons for this delay. It is true that, in accordance with the treaty provisions, the failure of any or all three remaining Non-Annex 2 States to ratify the treaty would not delay or block its entry into force. However, taking into consideration the current dynamics relating to the entry into force of the treaty (and, more generally, the disquieting situation in a broader area of nuclear arms control and non-proliferation), any new addition to the list of ratifying states should be welcome, and, in fact, facilitated as much as possible.

The CTBT will enter into force when it is signed and ratified by all states listed in Annex 2 of the treaty. It consists mostly of states, possessing nuclear weapons and/or advanced nuclear technology, whose participation is deemed absolutely necessary for achieving the purposes of the CTBT. Yet, the positions and actions of countries, which are not included in Annex 2 (Non-Annex 2 States) are also important. In this paper, the authors will explore the obstacles and difficulties that stand in the way of the three Non-Annex 2 States, which have not been able to ratify the CTBT so far. These three countries are often characterized as facing a complex interplay of political instability, financial issues, and security concerns, with domestic priorities often overshadowing international commitments. For example, in Somalia and Yemen, ongoing conflicts exacerbate the challenges associated with the treaty ratification, diverting governmental focus and resources. In turn, Nepal's socio-political landscape presents its own set of challenges that complicate and delay the ratification process. This paper aims to explore the multifaceted factors that block progress toward CTBT ratification among these states, illuminating the broader implications for internal and external constraints. By addressing and tackling these challenges, the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) could facilitate both the entry into force of the treaty and its subsequent successful implementation.

INTRODUCTION

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) represents an indispensable advancement in global nuclear arms control and non-proliferation efforts. It aims to ban all nuclear explosions whether for military or peaceful purposes.¹ The treaty provides for the establishment of the

¹ "The Comprehensive Nuclear-Test-Ban Treaty", Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), 1996, https://www.ctbto.org/our-mission/the-treaty/, accessed 12 February 2025>.

International Monitoring System (IMS) to ensure that no nuclear explosion goes undetected. As of January 2025, 306 certified facilities – of a total of 337 when complete – are operating around the world. The data collected by the IMS serves a number of other purposes, including disaster mitigation, such as earthquake monitoring and tsunami warning. The data collected also supports research in various fields, ranging from whale migration to climate change studies and predicting monsoon rains.² Thus, the CTBT's significance goes beyond arms control and non-proliferation as it supports sustainable development within a framework of international partnerships.

However, ratification of the CTBT is essential to enhance the treaty's effectiveness. In this context, it is important to examine political, social, and economic challenges delaying ratification by Non-Ratifying Non-Annex 2 States, namely Nepal, Somalia, and Yemen. Effective efforts toward the successful ratification process in these three countries could contribute to the universalization of the treaty and further facilitation of its entry into force.

In February 2023, CTBTO Executive Secretary Robert Floyd visited Somalia and commended the country's decision to sign the treaty, recognizing it as a manifestation of the country's commitment to global disarmament efforts. Somalia, the most recent state to sign the treaty, has demonstrated its readiness to engage with the international community and highlighted its potential for renewed collaboration in nuclear arms control and nonproliferation.³ In contrast, Yemen's ongoing conflict and humanitarian crises severely impede its ability to ratify the treaty, reflecting the intricate interplay between domestic instability and international commitments. Similarly, Nepal's approach to the CTBT is influenced by its geopolitical landscape, where aspirations for political stability and regional security shape its perspective on nuclear disarmament. The experiences of Nepal, Somalia and Yemen reflect the diverse motivations and barriers faced by Non-Ratifying Non-Annex 2 States. Facilitating integration of these states into the CTBT framework, which constitutes a part of global nonproliferation efforts, is crucial. Ratification of the treaty by these three states could positively contribute to the global non-proliferation landscape by promoting broader acceptance of the treaty provisions and encouraging further ratification of the CTBT by remaining yet nonsignatory/non-ratifying Annex 2 States.

NEPAL

Domestic Political Climate

There have been 13 changes of government in the last 15 years, including the 2008 transition to a federal democratic republic. A generally unstable political climate and the lack of consensus among political factions within the country, namely the Maoist Center, the Communist Party of Nepal (Unified Marxist-Leninist), and the Nepali Congress,⁴ have been among the major factors contributing to the delay in treaty ratification. Although Nepal signed the CTBT in 1996, it has yet to ratify it.

² "Somalia signs CTBT, "testament to unwavering commitment to peace, security", 19 June 2024, Kazakhstan National Data Center, https://kndc.kz/index.php/en/home-en/Smart%20Search/Joomla!%20Update/205-somali-yaszhtsh-a-bejbitshilik-pen-auipsizdikke-myz-ymas-mindettemeni-d-leli-retinde-ol-ojdy-2/, accessed 12 February 2025>.

 ³ "Adan Madobe meets with the Secretary of the Nuclear Test Ban Treaty Organization", The Somalia Investor,
 22 February 2023, https://somaliainvestor.so/adan-madobe-meets-with-the-secretary-of-the-nuclear-test-prevention-agency/, accessed 10 February 2025>.

⁴ Gaurav Bhattarai and Prakash Bista, "Fissure in South Asian regionalism in the age of great power rivalry: a small state's perspective.", May 2024, The Journal of Cross-Regional Dialogues, https://doi.org/10.25518/2593-9483.309, accessed 12 February 2025>.

Infrastructure and Technical Capabilities

One auxiliary seismic station AS068 "Everest" is to be built in Nepal as part of the IMS.⁵ Currently, its status is listed by the CTBTO as "planned", meaning that the construction of this station has not yet begun.

An infrastructure study has indicated that implementing the provisions of the CTBT in Nepal presents certain challenges due to the country's domestic settings. The establishment of the IMS facility requires the deployment of advanced technology and skilled personnel. However, Nepal currently faces limitations in terms of a specialized workforce with expertise in the treaty's technical aspects, as well as the presence of well-established nuclear research institutions. The IMS and the National Seismological System, however, are expected to collaborate to enhance seismic monitoring, which could be integrated into CTBT verification procedures.

The IMS data also plays a crucial role in supporting scientific climate action policies, which is particularly important for Nepal, recognized as one of the most vulnerable countries to climate change. This highlights the significance of the IMS for Nepal in various ways. However, Nepal's ability to host auxiliary seismic station in its current situation depends on receiving the necessary technical and financial assistance.

National and Diplomatic Priorities

For a landlocked nation like Nepal, diplomatic balance between China and India, two nucleararmed neighbors, is essential. This balance is influenced by the two countries' diplomatic actions vis-à-vis the CTBT.⁶ Similarly to Nepal, China signed the CTBT, but has yet to ratify it. India, however, has not demonstrated a strong inclination to sign the treaty. Nepal's nonaligned foreign policy, which is founded on peaceful coexistence, prevents it from taking strong stances that can be seen as favoring (or working against) the interests of one neighbor or another.⁷ This, in combination with urgent internal issues, for instance the nation's economic rehabilitation following the 2015 earthquake,⁸ helps to explain why Nepal has not yet ratified the CTBT. In order to help Nepal achieve real progress on the CTBT ratification, international partners should consider providing collaboration that advances the country's regional and national objectives in combination with further financial and technical support.

SOMALIA

Historical Context and Current Political Situation

Somalia's journey within the context of the CTBT has been shaped by its tumultuous history. Following the collapse of the Somali state in December 1990⁹, the country faced decades of

⁵ Station Profiles, CTBTO official website, <https://www.ctbto.org/our-work/station-profiles/, accessed 13 February 2025>.

⁶ "Nuclear research center must be opened for prosperity", Nepal Republic Media, 2018, <https://myrepublica. nagariknetwork.com/news/nuclear-research-center-must-be-opened-for-prosperity/, accessed 10 February 2025>.

K. B. Usha and Scott Romaniuk, "Non-alignment Policy", The Palgrave Encyclopedia of Global Security Studies, Springer International Publishing, 2022, https://doi.org/10.1007/978-3-319-74336-3_252-2, accessed 11 February 2025>.

⁸ "An Analytical Study on the Damage to School Buildings by the 2015 Nepal Earthquake and Damage Level-Based Reconstruction Experience", MDPI, 2024, https://www.mdpi.com/2075-5309/14/2/451, accessed 10 February 2025>.

⁹ "The Collapse of The Somali State: The Impact of the Colonial Legacy", Arcadia, 1994, <https://arcadia.sba. uniroma3.it/bitstream/2307/5265/1/The%20Collapse%20of%20The%20Somali%20State%20-The%20Impact%20 of%20the%20Colonial%20Legacy.pdf/, accessed 11 February 2025>.

armed conflict, social and political instability, and the effects of climate change.¹⁰ However, in recent years, Somalia has made significant efforts to establish a more stable and functional government, with international support helping to rebuild the nation's institutions. In recent years, the Federal Government of Somalia has received far more international support and embarked on enhancing the country's productive assets.¹¹ The election of a new government in 2022 marked a hopeful turn, as leaders have expressed commitment to international norms and agreements, including the CTBT. The Federal Republic of Somalia signed the CTBT on 8 September 2023, bringing the total number of signatory states to 187. The move came after Somalia's Minister of Foreign Affairs Abshir Omar Jama Huruse made a pledge to sign the treaty. During his visit to the country, CTBTO Executive Secretary Robert Floyd emphasized that Somalia's signature under the treaty represents a significant step in the country's commitment to global disarmament and non-proliferation. He noted that this move not only aligns Somalia with international standards but also enhances its security and diplomatic standing in the region.¹²

Reasons for Delay in Ratification

Although Somalia did sign the treaty, it has not yet ratified it. Foreign Minister Abshir Omar JamaHuruse highlighted the importance of moving towards ratification of the treaty, stating that signing the CTBT is a reflection of the government's dedication to peace and stability. He underlined the importance of international cooperation in addressing security challenges in the region. The minister's remarks resonated with the broader narrative that Somalia is committed to enhancing its diplomatic relations and ensuring a safer environment for its citizens and affirmed Somalia's commitment to these objectives and expediting the ratification process, thus highlighting the nation's dedication to global peace and security through multilateral cooperation.¹³

Media coverage of Somalia's signing the CTBT in 2023 was largely positive, framing Somalia's engagement with the CTBT as a crucial development in its post-conflict recovery. To support Somalia's ratification process, Robert Floyd announced that CTBT documents were being translated into Somali. He also offered the assistance of CTBTO officials to brief Somalia's parliament during the ratification proceedings.¹⁴ As Somalia embarked on that path, there is anticipation for the country to more actively toward ratification although the next steps are yet to be done.

¹⁰ "Addressing the root causes of Somalia's challenges", United Nations Development Program, 2024, <https:// www.undp.org/blog/addressing-root-causes-somalias-challenges/, accessed 12 February 2025>.

¹¹ "Somalia: Pathways to Economic and Institutional Reforms, Peace and Reconciliation, Environmental Restitution, and Sustainable development", AFDB, 2022, https://www.afdb.org/en/documents/somalia-pathways-economic-and-institutional-reforms-peace-and-reconciliation-environmental-restitution-and-sustainable-development-country-diagnostic-note-2022/">https://www.afdb.org/en/documents/somalia-pathways-economic-and-institutional-reforms-peace-and-reconciliation-environmental-restitution-and-sustainable-development-country-diagnostic-note-2022/">https://www.afdb.org/en/documents/somalia-pathways-economic-and-institutional-reforms-peace-and-reconciliation-environmental-restitution-and-sustainable-development-country-diagnostic-note-2022/, accessed 11 February 2025>.

¹² "Somalia signs CTBT, "testament to unwavering commitment to peace, security", Somali National News Agency, 2023, https://sonna.so/en/somalia-signs-ctbt-testament-to-unwavering-commitment-to-peace-security/, accessed 11 February 2025>.

¹³ "Somalia Reaffirms Commitment to Global Peace and Security", Ministry of Foreign Affairs & International Cooperation, 2024, https://web.mfa.gov.so/somalia-reaffirms-commitment-to-global-peace-and-security/, accessed 11 February 2025>.

Despite multiple climatic shocks and a complicated security situation, Somalia maintained progress on structural reforms,¹⁵ its recent actions and commitments indicate promising steps toward ratifying the CTBT. The combined efforts of the government supported by international partners, suggest that Somalia is poised to overcome the historical hurdles and emerge as a responsible member of the global disarmament community. "We understand the signing of the CTBT is not just a symbolic gesture but a testament to our unwavering dedication to global peace and security," stated the Somalian Foreign Minister.¹⁶

YEMEN

Similar to Somalia, Yemen singed the treaty in 1996 but has yet to ratify it. It is important to note that Yemen, as well as Nepal and Somalia, is a party to the Nuclear Non-Proliferation Treaty (NPT),¹⁷ which aims to prevent the spread of nuclear weapons and promote cooperation in the peaceful uses of nuclear energy. This adherence to the NPT demonstrates Yemen's broader commitment to the international non-proliferation regime.

Yemen's delay in ratifying the CTBT is caused by a number of interrelated causes. First, the ongoing challenges related to conflict and political instability have affected the strength and functioning of state institutions, including the parliament and other bodies involved in the ratification process. The government's primary focus is on addressing immediate security concerns and urgent humanitarian needs while ensuring the performance of essential governance functions, which naturally places treaty ratification lower on its list of priorities. Additionally, the severe humanitarian crisis¹⁸ has further strained already limited financial and human resources, making it challenging to allocate the necessary support for the ratification process, including awareness campaigns, legal reviews, and administrative tasks. This challenge is further compounded by the limited experience and expertise among authorized personnel responsible for carrying out these tasks. The overwhelming focus on addressing immediate humanitarian needs, such as food security, healthcare, and displacement, further overshadows other political and legal processes to ratify the CTBT.

In other words, Yemen's support for the NPT demonstrates its commitment to nonproliferation; however, the ongoing conflict, humanitarian crisis, and internal capacity constraints present substantial impediments to the ratification of the CTBT.

RECOMMENDATIONS

The delay in ratifying the CTBT by the only three signatory Non-Annex 2 States that are left – Nepal, Somalia, and Yemen — underscores the need for focused strategies to advance their ratification. Several recommendations are outlined below.

¹⁵ "The World Bank supports government institutions in Somalia to promote good governance, accelerate economic recovery and create jobs", The World Bank in Somalia, 2024, https://www.worldbank.org/en/country/somalia/overview/, accessed 12 February 2025>.

¹⁶ "Somalia signs CTBT, "testament to unwavering commitment to peace, security", CTBTO Preparatory Commission, Vienna International Centre, 2023, https://www.ctbto.org/news-and-events/news/somalia-signs-ctbt-testament-unwavering-commitment-peace-security/, accessed 11 February 2025>.

¹⁷ "Yemen View", Nuclear Threat Initiative, 2024, <https://www.nti.org/analysis/articles/yemenoverview/#:~:text=Yemen%20is%20a%20non%2d Nuclear, ,to%20be%20 pursuing%20 nuclear%20 weapons./, accessed 12 February 2025>.

¹⁸ "Civilians under siege", Yemen | International Rescue Committee (IRC), 2024, < https://www.rescue.org/ country/yemen/, accessed 12 February 2025>.

Enhancing Diplomatic Engagement and International Cooperation

Lack of international cooperation and diplomatic engagements address the delays in ratifying CTBT. It is important to enhance them among state signatories,¹⁹ especially non-ratifying Non-Annex 2 States. This involves creating platforms for dialogue that advance collaboration and promote the process of the ratification. Diplomatic efforts should focus on establishing bilateral and multilateral agreements that emphasize the benefits of ratifying the treaty, such as enhancing relevant partnership. Moreover, addressing unique concerns and priorities through workshops and diplomatic conferences, involving diplomats and experts from neighboring and other regional countries, can further clarify the treaty's benefits and show how ratification aligns with each country's development goals. International cooperation helps build the necessary frameworks for implementation.

Addressing Gaps in Scientific Knowledge and Professional Expertise

One of important points that delay ratification of the CTBT in Nepal, Somalia, and Yemen is a lack of scientific knowledge and professional expertise related to nuclear issues and the treaty's implications. To overcome this, it is essential to implement comprehensive educational programs aimed at enhancing understanding of nuclear non-proliferation and the benefits of the CTBT.²⁰ Collaboration of the CTBTO with academic institutions, research departments, facilitating knowledge exchange and providing technical workshops can help develop targeted training modules that address specific gaps in knowledge. In addition, hosting seminars and training, that emphasize the scientific and humanitarian rationale behind the CTBT, can inspire local advocates to become champions of the treaty within their communities.

Capacity Building Programs

Capacity building is important for non-ratifying states to effectively engage in the CTBT framework. This increases developing institutional capacities within nations such as Nepal, Somalia, and Yemen to monitor, report, and respond to nuclear-related issues. Implementing targeted training programs for government officials, civil servants, and technical staff can equip them with the skills to understand and advocate for the treaty and contribute to implementation of the CTBT verification regime.²¹ These programs should also focus on improving regulatory frameworks, as well as promoting effective communication between different government sectors involved in non-proliferation and disarmament efforts.

Creating a network of regional experts can facilitate the sharing of best practices and lessons learned from other countries that have successfully ratified the treaty. A similar, but not identical capacity building and awareness programs and activities should be considered for the civil society.

CONCLUSION

The CTBT represents a significant milestone in the global pursuit of nuclear disarmament and non-proliferation. The journey toward universal adoption could be facilitated if all three Non-Ratifying Non-Annex 2 States — Nepal, Somalia, and Yemen — ratify the treaty.

¹⁹ Winston P. Nagan and Erin K. Slemmens, «National Security Policy and Ratification of the Comprehensive Test Ban Treaty», 32 Hous. J. Int'l L. 1, 2009.

²⁰ Sameh Aboul-Enein, «Toward a Non-Nuclear World: The NPT Regime–Nuclear Disarmament and the Challenge of a WMDFZ in the Middle East, International Journal of Nuclear Security, 2017.

²¹ Ola Dahlman, P. Mykkeltveit, P., and Hein Haak, "The CTBTO Preparatory Commission and the PTS — an Organizational Perspective", Springer Science, 2009, https://link.springer.com/chapter/10.1007/978-1-4020-6885-0_9/, accessed 12 February 2025>.

What lays behind the delay in this step is that each of these countries faces unique obstacles rooted in their historical, political, and socio-economic contexts. For Nepal, persistent political instability and complex geopolitical environment has delayed the ratification process, as shifting governments grapple with pressing domestic concerns overshadowing international commitments. Yemen's ongoing conflict presents a challenging situation, where humanitarian crises and internal strife strongly divert attention away from ratifying treaties such as the CTBT. In Somalia, decades of conflict have damaged the governmental stability and focus, impacting its ability to ratify international treaties. Nevertheless, recent steps taken by the Somali government, as signing the CTBT, for example, indicate a nation's renewed dedication to international norms and cooperation.

The interplay between domestic instability and the lack of regional cooperation on disarmament and non-proliferation highlights the urgent need for targeted diplomatic efforts to encourage ratification in such contexts. Addressing these challenges requires a multifaceted approach that includes diplomatic engagement, capacity building, educational and training initiatives, enhancing international cooperation and creating platforms for dialogue that can help foster an environment conducive to ratification.

In conclusion, the path toward ratification of the CTBT by the states like Nepal, Somalia, and Yemen is achievable, but it necessitates concerted efforts from governments by itself. By addressing the unique challenges faced by these nations and promoting collaborative activities, the global community can work towards a future where the CTBT is not only signed but fully ratified and made operational. This will ultimately enhance global security, promote peace, and reinforce the collective commitment to a world free of nuclear testing. The engagement of these nations in the ratification process is not just beneficial for their own security and diplomatic standing but is also important for the integrity of the international non-proliferation and disarmament regime.

Science and Technology Conferences: History, Accomplishments, and Role in Supporting CTBT

■ Ibrahim Khalefa ■ Anum A. Khan ■ Olga Zhuravleva

ABSTRACT

This paper elaborates on the history, achievements, and impact of the Science and Technology Conferences (SnT) in supporting the Comprehensive Nuclear-Test-Ban Treaty (CTBT). The paper tracks the evolution of this platform from the inaugural "Synergies with Science" Symposium in 2006, the shift to the International Scientific Studies Conference in 2009, and the rebranding to SnT in 2011. These conferences have been instrumental in building the CTBT's verification regime and fostering global scientific collaboration in areas relevant for the CTBT. While challenges persist, the conferences have contributed greatly to advancing the CTBT's objectives. This paper also suggests future directions to maintain innovation and collaborative efforts.

INTRODUCTION

The primary goal of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) is to outlaw and ensure non-reoccurrence of nuclear weapon tests, thus aiding nuclear disarmament and non-proliferation. However, the Treaty faces challenges in achieving universal acceptance; geopolitical tensions and various perceived national interests impede the progress towards the treaty's entry into force.

The Article II.B, paragraph 26(f) of the CTBT provides that the Conference of the States Parties shall "consider and review scientific and technological developments that could affect the operation of this Treaty". For that purpose, a special body composed of independent experts, the Scientific Advisory Board may be established after the entry into force. However, since the Treaty has not yet entered into force and since significant advances in science and technology relevant to the CTBT operation have taken place, the need for an interim mechanism became evident. With this aim, the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO/PC) holds the Science and Technology (SnT) Conferences biennially. Initially known as the "Synergies with Science" Symposium in 2006, these conferences changed their name to the International Scientific Studies Conference in 2009 and adopted the SnT moniker in 2011. They bring together a wide range of technical specialists, scientists and decision-makers from around the world and offer a forum for information exchange, technological demonstration and cooperation. By guaranteeing that the advancements in scientific research on data processing, sensor technology, and other relevant areas are identified and considered, the conferences enhance the CTBT verification regime.

Based on the analysis of available data, this paper provides an overview of the history, key achievements, and prospects of the SnT conferences. It further demonstrates their important role in advancing the CTBT's goals and fostering a global culture of scientific collaboration and innovation for a more secure world.

SYMPOSIUM "SYNERGIES WITH SCIENCE, 1996-2006 AND BEYOND" (2006)

The first attempt of the CTBTO/PC to conduct a systematic review of advances in science and technology took the form of a scientific symposium, titled "Synergies with Science, 1996-2006 and Beyond" that was held in Vienna, Austria from 31 August to 1 September 2006. The symposium marked the 10th anniversary of the adoption of the CTBT, the purpose of the event was to celebrate the CTBTO/PC's achievements and to explore synergies with science that could be valuable for verification activities under the CTBT.¹The agenda covered three broad subjects: 1) methods and procedures for imaging the solid earth and oceans; 2) methods and procedures for imaging the atmosphere, and 3) modern data analysis techniques. Discussions also touched upon issues directly related to the CTBTO organizational development, namely, the influence of scientific advancements on the CTBTO/PC cost effectiveness and future work of its Provisional Technical Secretariat. As stated in the press releases, the event was attended by several hundred participants including scientists, diplomats and representatives of international organizations. The conference was open for media coverage with the possibility to arrange for interviews with participants. The live-stream on the public web site was organized to engage with a wider audience. The symposium was opened with addresses by high-level officials, including the IAEA Director General and the UN Under-Secretary-General for Disarmament Affairs. While the full list of participants is not publicly available, it is possible to make several conclusions about the speaker lineup. Being the first conference of its type, it hosted only 12 participants as speakers and moderators from 9 countries: Austria, Canada, China, England, France, Italy, Japan, the Netherlands and the USA. Only one woman had the role of a speaker, the youth was not represented. Key participants were affiliated with either universities and research institutions or relevant national agencies. While the NGOs as an interest group were not represented, at least two speakers from business were involved as stakeholders in the field of relevant technologies (Yahoo! and Google Earth).

INTERNATIONAL SCIENTIFIC STUDIES (ISS) CONFERENCE, 2009

In 2006, only a month after the symposium, on 9 October, the Democratic People's Republic of Korea (DPRK) announced that it had conducted a nuclear test. At the time, the International Monitoring System (IMS), being the technical core of the CTBTO's verification regime, was being established and operated in test mode; still, it proved capable of detecting a nuclear event and providing reliable data. Politically, the test underlined the need for an effective CTBT verification regime and for ensuring its technological and scientific capacity. An additional argument was another nuclear test conducted by the same state on 25 May 2009, less than a month before the International Scientific Studies Conference (ISSO9), where it was discussed along with the planned topics.

The Conference was organized within the framework of the International Scientific Studies Project launched in 2008.² The aim of the ISS project was twofold: 1) to evaluate the readiness and capability of the CTBT verification system to detect nuclear explosions worldwide, thus,

¹ CTBTO Preparatory Commission, "CTBTO Preparatory Commission holds two-day scientific symposium", CTBTO Preparatory Commission, 2006, https://www.ctbto.org/news-and-events/news/ctbto-preparatory-commission-holds-two-day-scientific-symposium, accessed 10 February 2025>.

² CTBTO Preparatory Commission, "International Scientific Studies Conference, Vienna, 10-12 June 2009", CTBTO Preparatory Commission, 2009, https://www.ctbto.org/sites/default/files/2022-08/issafc2_web.pdf/, accessed 10 February 2025>.

assessing the current state of affairs, and 2) to strengthen CTBTO/PC's cooperation with the global scientific community, thus, allowing the organization to keep pace with scientific and technological progress in the long term. The Conference took place from 10 to 12 June 2009 and, according to official publications, attracted around 600 participants from 99 countries, including Annex 2 States that had not ratified the Treaty (China, Egypt, Iran, Israel, USA) and two Non-signatory States (India and Pakistan).³ As for the speaker lineup, among 55 speakers and moderators from around 24 countries (including the USA, China, India and Israel), only 6 were women (as shown in Graph II), the youth demographic group was not represented. In terms of key participants' affiliations, the overall situation did not change significantly: universities, scientific institutions and national governmental bodies (including defense agencies) remained prevalent. However, the positive dynamics in the diversity can be noted, since representatives of international organizations (UN World Meteorological Organization), NGOs (Center for the Promotion of Disarmament and Non-Proliferation — CPDNP, International Seismological Centre); even speakers from the press (Yomiuri Shimbun) took part.

The agenda covered 8 topic areas: seismology, infrasound, hydroacoustics, radionuclide monitoring, atmospheric transport modeling, system performance, on-site inspection and data mining. Apart from oral presentations, more than 200 posters were presented with seismology (53), on-site inspection (34) and radionuclide monitoring (31) being the most popular thematic fields. The panel on on-site inspection involved valuable contributions that provided comparisons between monitoring processes that exist in the functioning arms control and disarmament regimes, i.e. those of the OPCW,⁴ IAEA and the US-Russia bilateral treaties. While the conference did not issue formal conclusions or recommendations, its materials were published in the Book of abstracts, followed by the report titled "Science for Security: Verifying the Comprehensive Nuclear-Test-Ban Treaty," in which topic coordinators summarized their thoughts on the scientific contributions to their fields made by participants. Later, a publication titled "Possible Projects for the CTBTO arising from the 2009 International Scientific Studies Conference, 10-12 June 2009" was issued. Its authors pointed out that many research contributions presented at the ISS09 were driven by the experts' individual scientific interests, and with that report, the authors attempted to tailor the conference outcomes to the future CTBTO's verification regime needs.

SCIENCE AND TECHNOLOGY CONFERENCE 2011

The first scientific event under the title "Science and Technology Conference" was held from 8 to 10 June 2011. The agenda was partly influenced by the Fukushima nuclear power station disaster that demonstrated the importance of CTBTO technological capacity for the global nuclear emergency response framework. A special session was devoted to the event and its aftermath. The contributions not only demonstrated the usefulness of data provided by the IMS in identifying and defining events of that kind (e.g. in discriminating between reactor accidents and possible nuclear explosions), but they also described the impact of such events on the CTBT verification system (e.g. the impact on the sensitivity of the IMS radionuclide network). Other thematic sessions (in total 350 scientific submissions and posters) covered the following topics: 1) "The earth as a complex system" aimed at discussing issues related to monitoring issues caused by various earth's complexities, 2) "Understanding the nuclear

³ As of September 2009, 181 countries had signed the Treaty and 150 had ratified it. China, Egypt, Indonesia, Iran, Israel, the US, as well as the DPRK, India and Pakistan had yet to ratify the Treaty.

⁴ Organisation for the Prohibition of Chemical Weapons.

explosion source", devoted to issues of identification of and distinguishing among nuclear events, 3) "Advances in sensors, networks and observational technologies" and 4) "Advances in computing, processing and visualization for verification application," discussing technological capabilities needed for observational verification activities, and 5) "Creating knowledge through partnerships, training and information/communication technology", where an overview of transnational cooperation mechanisms promoting transparency and openness in science and policy was presented.

The SnT 2011 attracted around 800 participants. In the promotional brochure, it was mentioned that financial support could be provided to a limited number of participants, but it was strongly recommended to first seek funds from non-CTBTO sources. According to the program, among 148 speakers, only 26 were women (as shown in Graph II), and the youth demographic group was not represented. Geographically, around 35 states were represented by speakers and moderators, with the USA (~30), Russia (~13) and Germany (~13) having the largest numbers of participants. Speakers from Egypt, India and Iran (Annex 2 States)⁵ took part. In general, more than 60 organizations were represented by participants in the speaker lineup with no prominent changes in the character of organizations in comparison to the previous conference. As a result of the SnT 2011 Conference, a Book of abstracts was published, followed by a report titled "Scientific Advances in CTBT Monitoring and Verification" reviewing the materials presented. Even though no separate publication reflecting on the outcomes of the conference for the CTBT was issued, the mentioned report identified certain gaps in the range of scientific contributions presented at the SnT 2011 that paved the way for research to be presented at future conferences.

SCIENCE AND TECHNOLOGY CONFERENCE 2013

The SnT 2013, held in Vienna from June 17 to 21, brought together over 750 participants from around 100 countries to promote CTBT verification and strengthen ties with the scientific community. Keynote speeches by figures like Hans Blix and Ellen Tauscher highlighted the role of science and technology in global nuclear disarmament efforts. The agenda featured themes such as "The Earth as a Complex System", "Events and Their Characterization", and "Advances in Sensors, Networks, and Processing", reflecting the broad scope of scientific exploration central to CTBT monitoring and verification. Special sessions addressed the DPRK's February 2013 nuclear test,⁶ detected by CTBTO stations. The issue of reducing radioxenon emissions from radiopharmaceutical facilities was also discussed.⁷

More than 300 presentations explored non-verification uses of CTBTO data, such as monitoring climate change via whale vocalizations and improving seismic detection with WWII ordnance. A session examined the 2013 meteor explosion in Russia, detected globally by CTBTO infrasound stations. The conference also introduced initiatives like the Young Scientists Evening and a prize for the best young scientist presentation. The media coverage was minimal, with only CTBTO PrepCom covering some aspects of the event.

⁵ As of 2011, the CTBT was signed by 182 and ratified by 153 states, it needed ratification by 6 signatories, and adherence and ratification by India, Pakistan, and the DPRK to enter into force.

⁶ CTBTO News Article, "2013 DPRK Announced Nuclear Test", CTBTO Preparatory Commission, 2013, <https// www.ctbto.org/our-work/detecting- nuclear-tests/2013-dprk-nuclear-test/, accessed 10 February 2025>.

⁷ CTBTO News Article, "The Science and Technology Conference 2013", CTBTO Preparatory Commission, 2013, <https://www.ctbto.org/ news-and-events/ news/science-and-technology-conference-2013/, accessed 10 February 2025>.

SCIENCE AND TECHNOLOGY CONFERENCE 2015

The SnT 2015 was held from June 22 to June 26. The conference drew more than 1,000 participants from over 70 nations, featuring 550 abstracts and poster presentations, making it the largest event in this series to date. The conference was inaugurated by Mr. Lassina Zerbo, former CTBTO/PC Executive Secretary, who emphasized the critical role of science in fostering peace and highlighted achievements from past conferences, including advancements in machine learning, self-calibrating infrasound sensors, and high-resolution beta-gamma spectrometry. Keynote speakers stressed the importance of scientific innovation in CTBT verification and the need for global collaboration in nuclear disarmament and non-proliferation.⁸ Special sessions and panel discussions covered a range of topics, including the application of new and emerging technologies in nuclear security, the role of citizen networks in monitoring efforts, and the ongoing societal benefits derived from CTBT data. The conference also introduced the theme of "Performance Optimization", which encompassed discussions on network performance, trends in information technology, and logistics and lifecycle management.

Additionally, the conference underscored the need to engage young scientists and encourage partnerships through initiatives such as the Young Scientists' Evening and research grants provided by the European Union. In the closing session, the focus was placed on achieving quality in the SnT conferences and motivating attendees to utilize the CTBTO's online resources, such as e-learning modules and the virtual Data Exploitation Centre (vDEC). There was a lack of information regarding youth and women's participation due to the limited media coverage, resulting in no reports or summaries being available online.

SCIENCE AND TECHNOLOGY CONFERENCE 2017

The SnT 2017 occurred from June 26 to 30. This conference drew nearly 1,000 participants from over 120 nations, featuring 650 submitted abstracts, close to 400 posters, and more than 100 oral presentations. For the first time, both women and men were prominently featured as speakers throughout the week, and the conference was co-led by a man and a woman.⁹ The high-level opening session included keynote addresses from former CTBTO Executive Secretary Mr. Lassina Zerbo, Princess Sumaya of Jordan, and other distinguished representatives. The event also incorporated a strong youth presence, with over 70 members of the CTBTO Youth Group from more than 50 nations participating.

A theme "Monitoring for Nuclear Explosions in a Global Context" was included in the programme for the first time. A special session and panel discussions explored a variety of subjects, such as the challenges and progress in the IMS, the role of academia in facilitating the Treaty's entry into force, and the CTBT's relevance in a rapidly changing global environment. The conference showcased innovative presentations concerning the use of mobile phones for seismic monitoring and best practices for using social media for advocacy. The CTBTO Youth Group was notably involved, with members presenting their own research, taking part in workshops, and engaging in the "Youth Newsroom" initiative, which aimed to share the conference experience with broader audiences through diverse media formats. The

⁸ CTBTO News Article, "SnT2015 kicks off", CTBTO Preparatory Commission , 2015, <https://www.ctbto.org/newsand-events/news/snt2015-kicks/, accessed 10 February 2025>.

⁹ Lassina Zerbo, Former CTBTO Executive Secretary's Article on SnT2017, LinkedIn, 2017, https://www.linkedin.com/pulse/ctbt-science-technology-conference-2017-peace-lassina-zerbo, accessed 10 February 2025>.

conference emphasized the intersection of science and policy, underlining the necessity of simplifying complex scientific information for diplomats and policymakers. Three creative projects from the Youth Group were presented to raise public awareness of the CTBT.¹⁰ The conference brought attention to the concept of "science diplomacy" as a pathway to promote the CTBT,¹¹ with suggestions for establishing summer schools and scholarship schemes focused on nonproliferation. The speakers stressed the necessity for collaboration between scientific and political realms, youth participation, and maintaining optimism in addressing global challenges. The conference highlighted the vital role that scientific and technological advancements play in verifying compliance with the CTBT and emphasized the significance of international cooperation in furthering nuclear disarmament and non-proliferation. The SnT2017 wrapped up with a call for cooperative scientific efforts in pursuit of peace and development, stressing the need for scientific progress and diplomatic initiatives to attain a nuclear threat-free world.

Media coverage increased compared to past events, with the Arms Control Association providing a separate daily summary of the conference proceedings and the CTBTO offering recorded videos on their YouTube channel.

SCIENCE AND TECHNOLOGY CONFERENCE 2019

The primary agenda of the 2019 SnT conference was to advance the verification science of CTBT. In 2019, there were 184 signatory states, and 164 ratifications completed after Zimbabwe's ratification. The Conference not only focused on bolstering verification, but also supported civil applications of the international monitoring system within the treaty.

As the geopolitical landscape in 2019 was in a flux, the timing of this conference was crucial. It is so because global nuclear arms control was faced with several challenges, such as the collapse of the INF Treaty in 2019 or the US withdrawal from the JCPOA in 2018. The Non-Proliferation Treaty (NPT) Preparatory Committee Meeting for 2020 Review Conference mentioned the lack of progress regarding disarmament. In such circumstances, the NPT PrepCom referred to an important role CTBT Preparatory Commission was playing regarding disarmament and non-proliferation education.¹²

The conference showcased geographic diversity with nearly a hundred states participating in the conference. It was also the first time that the issue of gender within science and technology was given a special spotlight in the SnT conference, with the female representation reaching just below 50 percent¹³ (See Graph II).

¹⁰ Arms Control Association, "The CTBTO 2017 Science and Technology Conference: Day 4", Arms Control Association, 2017, https://www.armscontrol.org/blog/2017-06-29/ctbto-2017-science-technology-conference-day-4/, accessed 10 February 2025>.

¹¹ Arms Control Association, "The CTBTO 2017 Science and Technology Conference: Day 5", Arms Control Association, 2017 https://www.armscontrol.org/blog/2017-06-30/ctbto-2017-science-technology-conference-day-5/, accessed 10 February 2025>.

¹² Robert Einhorn, "The 2020 NPT Review Conference: Prepare for Plan B", UNIDIR, 2020, <https://unidir.org/ wp-content/uploads/2023/05/The-2020-NPT-Review-Conference-Prepare-for-Plan-B.pdf#:~:text=Third%20 Session%20of%20the%20Preparatory%20Committee%20for,the%20Non%2DProliferation%20of%20Nuclear%20 Weapons%2C%2010%20May/, accessed 10 February 2025>.

¹³ Ilya Kursenko, "Passion and Diversity at the 2019 CTBTO Science and Technology Conference", Arms Control, 2020, <https://www.armscontrol.org/blog/2019-06-30/passion-diversity-2019-ctbto-science-technology-conference/, accessed 10 February 2025>.

Moreover, there was notable youth representation, comprising at least 25 percent of all participants. The Forum on Global Citizenship and Youth Inclusion and Ban Ki-moon Centre co-organized panels for young leaders to discuss the role youth can play to fulfil CTBT objectives as well as other UN goals. The idea was to foster discussions on nuclear non-proliferation, diplomacy, and international law. Key topics in which youth participated included the CTBT's role in combating nuclear threats, enhancing youth awareness, and supporting gender diversity in scientific and diplomatic efforts. The conference also projected that the career preferences among male/female CTBTO youth group members were leaning towards international monitoring system, policy making, on-sight inspections and outreach activities.¹⁴

SCIENCE AND TECHNOLOGY CONFERENCE 2021

The SnT 2021 conference coincided with the 25th anniversary of the CTBT. The primary focus of the agenda was on further development of verification through technical and scientific capabilities, including AI applications and enhanced sensor networks. Due to COVID-19 pandemic, the conference followed a hybrid format of participation. Over 1600 participants took part in the conference. Although the virtual attendance allowed broader participation, the media coverage was low — unlike during the 2019 conference. The 2021 conference achieved impressive geographic diversity; however, a lion's share of participants came from North America and Western Europe, with significantly less — from Asia. The 2021 conference also saw a decrease in women participation to approx. 32 percent. Participants belonging to the "youth segment" were primarily attracted to non-proliferation issues. They were also involved in On-Site Inspection (OSI) educational initiative for young professionals with technical backgrounds, advanced verification technologies and media coverage hands-on training via Citizen Journalism Academy.

In 2021, the geopolitical landscape saw many important developments including postponement of the Review Conference for the NPT; the extension of the New START Treaty and DPRK's continued development of nuclear and ballistic missile capabilities. Moreover, throughout 2021, there were continuous, though unsuccessful, efforts to revive the JCPOA. Amidst such growing uncertainties, the importance of CTBT's verification framework to prevent nuclear testing was often referred to as crucial in promoting international security.

SCIENCE AND TECHNOLOGY CONFERENCE 2023

Despite further deterioration of global political situation and exacerbation of several conflicts, including around Ukraine, SnT 2023 saw a record increase in participation, surpassing the number of 2000 people from 148 countries. 80 percent of the participants were inperson attendees and 20 percent attended online, as virtual components were added by the organizers for global inclusivity. The major theme of the conference was to highlight innovation as a key to verification science and technical advancements and importance of universalization of the CTBT.

Women included at least 35 percent of the total attendees. The "NextGen for the CTBT" initiative helped to further engage the youth in discussions related to CTBT implementation,

 ¹⁴ S. Bukhalina and M. Zadorozhnaia, "T5.3-O3 Integration women technicians in CTBTO", 2019 SnT Conference, 2019, < https://ctnw.ctbto.org/ctnw/abstract/30191/, accessed 10 February 2025>.

innovation in monitoring technologies and nuclear security. The 2023 conference successfully made the youth voices heard in the support of CTBT. The themes that included youth were gender parity in nuclear disarmament, youth's contributions to CTBT's progress, awareness building among young students regarding nuclear issues, empowering the youth as torch bearers for science and security, engage youth in shaping a nuclear free world for generations to come. Regarding geographic representation of women, the representation from North America and Western Europe remained high. Nevertheless, there was a notable increase in African participants.

A welcome event, with Somalia ratifying the CTBT, added the momentum to the universalization of the CTBT. Regarding media coverage, despite 11 journalists sponsored to attend the conference, not much media coverage of the conference was seen. Nevertheless, the hashtag Snt2023 was posted on twitter by CTBTO official twitter page Russian Mission in Vienna, National Nuclear Security Administration (NNSA) and participants.

CONCLUSION

At the time when the CTBT has yet not entered into force and in the resulting absence of Scientific Advisory Board, SnT Conferences can be considered as a "precursor" for the CTBT's science and technology review mechanism. At the same time, SnT conferences turned out to be an instrument of much wider outreach to various communities highlighting the importance of the CTBT in terms of global security, arms control, non-proliferation and development — something the Scientific Advisory Board was not supposed to have as a function. Usually lasting for 2–5 days, the SnT conferences feature panel discussions, technical sessions, and keynote speeches. They address topics as data processing, new sensor technologies, and the scientific and civil uses of CTBT data. Key priorities include fostering international scientific collaboration to keep the CTBT's verification system effective.

In terms of participants diversity and agenda scope, SnT conferences saw significant growth: from only 3 panel sessions with 12 speakers and "several hundred participants" in 2006 to the intense programme encompassing 24 scientific topics distributed amongst the five vast themes covered in 101 oral presentations and 455 e-poster presentations with the record attendance of over 2000 participants in 2023. It is pertinent to note that the agenda currently includes relevant topics belonging not only to the natural sciences (physics, chemistry, geology, etc.), but also to political science, thus incorporating knowledge on security, non-proliferation and disarmament issues. The general dynamic in the conferences' geographical scope can also be considered positive: participants from 99 states took part in 2009, and, even though only 70 states were represented in 2015, by 2023 the number increased and participants from 148 states were present. Among the participants, Annex 2 States are represented quite significantly, especially, the USA, followed by Russia, China, France, Germany, as well as Egypt, Iran, Israel and even CTBT Non-signatory states – India and Pakistan. It is also important to note that Iran—Israel relations are conflictual in nature, nevertheless, representatives from both states attended the SnT conferences. This reflects that SnT Conferences can also provide a platform for dialogue necessary to ease regional tensions, thereby, acting as confidence building measure (CBM) tools.

Youth and women engagement is also on the rise: in the period 2006–2011, the percentage of women among speakers did not exceed 17,5%, and the youth as a demographic group was not represented. However, in 2013, there were modest advancements in recognizing youth, highlighted by introducing a special event called Young Scientists Evening and a prize awarded for the best presentation by a young scientist. This event continued in 2015, and in 2017, the conference experienced a noteworthy rise in participation from both the youth and

women. For the first time, the conference included two "Conference Leaders" (a man and a woman). Both men and women were prominently featured as speakers, with more than 70 members from the 200 CTBTO Youth Group participating in the conference, along with six special events dedicated to youth. In the last SnT conference of 2023, inclusion of women was at 35 percent which was lower in comparison to 49 percent in 2019, but the last conference successfully made the youth voices heard on the issues pertinent to the CTBT. Overall, the outreach effect of the SnT conferences also increased with the introduction of the hybrid format of participation.

These SnT conferences are significant in the long term, as they help to preserve and improve the CTBT's verification capabilities. They contribute to the credibility and dependability of the global verification system by consistently incorporating new scientific and technological developments, building and preserving international trust, ensuring compliance with the Treaty, and contributing to global peace and security.

RECOMMENDATIONS

In order to strengthen global advocacy for the ban on nuclear testing and for the entry into force of the CTBT, there is a need to keep the positive dynamics through diverse audience engagement, especially, of such social groups as the youth and women. All-encompassing regional representation, including CTBT Annex 2 and non-signatory states, remains a priority as well. Therefore, it can be recommended to continue the practice of allocating grants providing financial support to prospective candidates from the mentioned groups and underrepresented regions (e.g. South East Asia, the Pacific and the Far East). Specific targeted outreach initiatives for experts and scientists from the Annex 2 and especially non-signatory states can also be beneficial in this regard. Similarly, SnT conferences can also provide an opportunity to organize a panel for young parliamentarians. Continuous connections with the existing initiatives promoting inclusion of women and youth in STEM¹⁵ are necessary. It would also be desirable to invite more international Civil Society Organizations, especially those which focus their efforts on the intersection of science and arms control (especially, but not exclusively, in the nuclear domain) – such as the IPPNW or the Pugwash Conferences on Science and World Affairs (both Nobel Peace Prize recipients).

With the aim of creating a live community of active and interested members, it might be pertinent to consider establishing a collaborative online platform that would enable participants to share research, carry on conversations, and work together on projects. This could increase the intensity of cross-domain collaboration and bring benefit to the CTBTO/PC with innovative and out-of-the-box solutions to pertinent issues related to nuclear disarmament. This recommendation might be in line with the proposition voiced in 2023 by the panelists for the audience to contact them if they had any fresh and innovative ideas. Such a platform might incorporate virtual networking events, webinars, and forums to guarantee continued engagements. The platform could also serve as a feedback mechanism.

It could also be recommended to put virtual and augmented reality (VR/AR) experiences into practice, i.e. to make use of VR/AR technologies to develop immersive experiences that showcase nuclear explosion impact, on-site inspection simulations, and CTBT-related technology. Participants' comprehension and involvement can be improved by these experiences, particularly for those who are beginners in the field.

¹⁵ For example, the IAEA Marie Sklodowska-Curie Fellowship Programme.

Regarding themes for future SnT conferences, it may be desirable to better publicize the civilian/peaceful uses of monitoring systems, in addition to improvement in verification technologies and scientific collaborations. Thus, future themes could focus on climate change and environmental monitoring, disaster risk reduction, space science and planetary monitoring, ethical and social dimensions of sciences, cross disciplinary collaborations to address global challenges in the fields of oceanography, meteorology, and urban resilience and cooperate scientific studies regarding impacts of nuclear testing on ecosystems.

From the point of view of preserving institutional memory, it might be useful to revive the practice of publishing reports reflecting on the results of the conference not only from the purely scientific perspective, but from the one of the CTBTO and identifying gaps in contributions that could be of further interest to the organization. This might become especially important when the time comes to incorporate the achievements of the SnT Conferences into the future Scientific Advisory Board mechanism. Moreover, the graphical representation of participants from countries and the segregation of online and in-person speakers also needs to be added in future reports. Although statistical data in the form of regional distribution and clusters of participants individually from countries, especially from Annex 2 States to formulate future strategies for further engagements.

In terms of media coverage of SnT conferences, this area needs significant improvement in communication strategies, since, unfortunately, there was very little social, print and electronic media coverage that did not do justice to the scale at which the conferences were organized, as well as to the important issues these conferences aim to cover. To bring about universal awareness and especially in underrepresented regions and in CTBT Annex 2 and non-signatory states, there should be a solid perception-building strategy that could include spreading press-releases among all prominent international newspapers, electronic media as well as following a collective social media strategy before, during and after the conference.

ANNEX

Scheme I: Timeline and Key Achievements of the SnT Conferences

"Synergies with Science" symposium: the first attempt to conduct a systematic review of advances in science and technology relevant to the CTBT, as well as to actively engage with the global scientific community.	2006	2009	International Scientific Studies Conference was marked by developing a strategic approach via the ISS Project, participation of Annex 2 and Non-signatory States' representatives, inclusion of international organizations, NGOs and press representatives in speakers lineup incorporating the lessons	
The first Science and Technology Conference provided analysis of the CTBTO technological capacity for the global nuclear emergency response framework based on the lessons learned from the Eukuchima	2011		learned from the DPRK's nuclear tests and the experience of other arms control regimes in terms of inspections, and establishing a mechanism of keeping the record of and developing a critical and reflective approach to the conference's results.	
accident, and benefited from adding to the agenda a session on creating knowledge through partnerships, training and information / communication technology.		2013	SnT2013 focused on monitoring the Earth's complex systems, analyzing events, and advancing sensor technologies. Highlights included discussions on the DPRK's February 2013 nuclear test. The conference featured the Young Scientists Evening and awards for outstanding presentations, emphasizing the importance of engaging the next generation of researchers. SnT2017 introduced the new theme "Monitoring for Nuclear Explosions in a Global Context". The event highlighted such advancements as mobile phone seismic monitoring. The CTBTO Youth Group played a significant role, engaging in workshops and creative projects to raise awareness about the CTBT. The conference emphasized science diplomacy, international collaboration, and youth involvement in advancing nuclear disarmament.	
SnT2015 highlighted advancements in CTBT verification, including machine learning and infrasound sensors. Discussions covered nuclear security, citizen monitoring, and the societal benefits of CTBT data. The "Performance Optimization" theme addressed network performance and IT trends. Initiatives, like the Young Scientists' Evening, were added to encouraging attendees to use e-learning modules and vDEC to expand their expertise.	2015			
		017		
SnT2019 continued the positive dynamics in the youth engagement and benefited from adding to the agenda topics seeking to identify how scientific developments and cooperation can support national needs and frame policy objectives in support of the civil applications of the CTBT techniques and data used for test ban verification.	2019			
		2021	The agenda of the SnT2021 was significantly shaped the COVID-19 pandemic and sought to address the resilience of the CTBT system, aspecially, agrid, COVID-19, disruptions. The	
SnT2023 sought to maintain awareness of emerging technologies relevant to CTBT monitoring, 051 preparedness and related areas. The conference brought attention to such pertinent issues as integration of early career scientists, including the CTBTO Youth Group and the Young Professional Network, in the CTBT circuit. Virtual components were added to continue the success of hybrid format of participation at earlier conference.	2023		conference marked the 25th anniversary of the opening for signature of the CTBT and allowed for hybrid format of participation (in- person and online).	



Graph I: Women Representation in SnT by Region (%)

Graph II: Women Representation in SnT Conferences



Graph III: SnT Attendance and Contributions Overview



Former Nuclear Test Sites: Possible Approaches to Address the Legacy of Testing Programs

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ABSTRACT

This article examines the legacies of nuclear testing, with a focus on Algeria and Kazakhstan, as emblematic cases of environmental, health, and socio-political consequences. From 1960 to 1966, French nuclear tests in Algeria resulted in significant radioactive contamination, health crises, and unresolved grievances rooted in colonial inequalities. Despite Algeria's advocacy for transparency and reparations, remediation efforts remain hindered by political and economic challenges. Conversely, Kazakhstan, which had seen numerous Soviet-era nuclear tests at the Semipalatinsk test range from 1949 to 1989, represents a proactive approach through international cooperation and infrastructure dismantlement, including activities under the Cooperative Threat Reduction (CTR) Program. Yet, pervasive public health impacts and environmental degradation persist. These cases underscore the need for transparency, accountability, and effective and cooperative international frameworks to address the harmful consequences of nuclear testing.

INTRODUCTION

The legacy of nuclear testing represents one of the most complex challenges in addressing the consequences of military and technological advancements. These tests, often conducted in remote or politically marginalized regions, have resulted in widespread environmental contamination, profound health crises, and long-lasting socio-economic disruptions. Algeria and the Republic of Kazakhstan are essential case studies in understanding the multifaceted nature of these legacies, shaped by their unique historical contexts and geopolitical circumstances.

In Algeria, nuclear testing was conducted by France between 1960 and 1966 – starting during the war for independence (from France) and ending 4 years after the war was over and Algeria gained independence. Altogether, 17 tests carried out in the Sahara Desert, comprising both atmospheric and underground explosions, left a legacy of radioactive contamination and health issues for local communities. France's continued reluctance to disclose comprehensive information regarding these tests or engage in robust remediation has further complicated Algeria's efforts to address the aftermath. These challenges are compounded by the enduring inequalities associated with colonialism, making Algeria's pursuit of justice a national and international endeavor. Kazakhstan, meanwhile, experienced a more extensive testing program under the Soviet nuclear weapons program, with over 450 detonations taking place from 1949 to 1989. 116 were atmospheric tests conducted in 1949-1963; the rest were underground, including one conducted within the framework of the JVE (Joint Verification Experiment, launched by the US and the USSR in 1988). The tests, conducted primarily at the Semipalatinsk (now Semey) Test Site, exposed, according to

and 340 underground

From 1949 to 1989

August 29, 1991

some reports, an estimated 1.6 million people to radiation,¹ creating significant public health and environmental crises. Following the dissolution of the Soviet Union, Kazakhstan has pursued a collaborative approach to remediation, developing and leveraging international partnerships to dismantle nuclear infrastructure and mitigate contamination. Despite these efforts, the scale of the damage underscores the continuing need for support and innovation in addressing the long-term effects of nuclear testing.

These two cases provide critical insights into the global implications of nuclear testing. They highlight the intersection of environmental and human rights issues, the importance of international cooperation, and the need for effective frameworks to address historical injustices. By examining the experiences of Algeria and Kazakhstan, this article aims to contribute to the broader discourse on nuclear rehabilitation, emphasizing the role of accountability, transparency, and collaborative action in addressing the legacies of nuclear weapons testing.

Analyzing the legacies of nuclear testing programs through the impacts of those programs on ecosystems and communities can also be tricky for some reasons. To start with, the CTBT itself does not contain or mention any requirement specifically designed to cover test sites, thereby providing a relatively weak legal basis for elaborating ideas and action plans within the framework of the Treaty. This conclusion, correct as it may be, can be effectively countered by numerous incontestable historical facts showing the huge role which open sciencebased discussion about harmful consequences of nuclear tests played in generating public political pressure and conducive political environment enabling the successful conclusion of the CTBT and ensuring unprecedentedly high numbers of its Signatories and ratifying States; furthermore, while the Treaty is not in force yet, we should not close our eyes on the arguments which helped drew massive public support to the idea of banning nuclear weapon tests. Still another dimension of the argument is that trying to legitimize or overexploit this set of problems in the context of preparations for the Treaty's entry into force at this stage risks adding more complications to the process and excessively "discouraging" some of the States. To sum it up, the authors believe that while the issues relating to the legacies of the nuclear testing programs should be viewed as legitimate in research of the nuclear test ban, caution and a sense of measure are required to avoid making a difficult road towards the entry into force even more complicated.

5		
	ALGERIA	KAZAKHSTAN
Number of Nuclear Test Sites	2: Reggane, In Ekker	4: Semipalatinsk (Semey), Say-Ötes, Lira, and Azgyr*
	17: 4 atmospheric,	456: 30 surface, 86 aerial,

Table 1. Nuclear Tests in Algeria and Kazakhstan

Number of Nuclear Tests

Operational Period and

Closing Date

* - incl. sites for peaceful nuclear explosion (PNE) experiments

** - the last test took place on February 16, 1966. No official closing date was indicated

13 underground

From 1960 to 1966**

Nuclear Threat Initiative (NTI), "Semipalatinsk Test Site," Nuclear Threat Initiative, 2025, https://www.nti.org/ education-center/facilities/semipalatinsk-test-site/, accessed 12 February 2025>.

EXPLORING THE LEGACY OF NUCLEAR TESTING IN ALGERIA: HISTORICAL CONTEXT AND RESPONSE

Between 1960 and 1966, France carried out 17 nuclear tests in Algeria, which was, at that time, its protectorate. These tests included the first French nuclear explosion — on 13 February 1960, France detonated an atomic bomb with a yield of 65 kilotons from a 105-meter tower, code-naming this test 'Blue Jerboa' ('Gerboise Bleue').² Eleven tests were conducted after the Evian Accords (1962), which granted Algeria independence but allowed France to use the sites until 1967.

There were two nuclear test areas in Algeria, both in the Sahara Desert: Sites 50 km south of Reggane on the Tanezrouft plain (Southwest of Algeria) where the Saharan Military Test Centre (Centre saharien d'expérimentations militaires — CSEM) was deployed. In addition to 'Blue Jerboa', in 1960-1961 three other tests were carried out. The total explosive yield released in the four tests was between 40 and 110 kt TNT equivalent.

Two sites in the region of In Ekker (South of Algeria) — Taourirt Tan Afella, where all nuclear tests were conducted in tunnels, and Adrar Tikertine, where the 'Pollen experiments' on the dispersion of plutonium in the air were conducted. The Oasis Military Test Centre (Centre d'expérimentations militaires des oasis — CEMO) was deployed in this area. Between 1961 and 1966, there were 13 underground nuclear explosions carried out in In Ekker. In 1966, France shifted its test sites to the uninhabited atolls of Mururoa and Fangataufa in the Pacific Ocean, where from 1966 to 1996, it conducted 194 tests.³

Consequences of Nuclear Explosions: Assessment of the Legacy

In 1999, at the request of the Algerian Government, the IAEA carried out a study of the radiological situation at the former French nuclear test sites in this country.⁴ Thirty-three years after the last underground explosion, the Agency's inspectors came to the field measurements. They obtained field samples to assess the level of radiological contamination in this area.

The findings revealed that most of the areas at the test sites had little residual radioactivity. The area of Reggane was an entirely arid desert (as was the case when the tests had been run). The closest inhabited location is the town of Reggane, with a population of approximately 32.9 thousand people,⁵ which is 50 km from this test site. The underground test site at In Ekker — Taourirt Tan Afella — was nominally restricted, although intermittent grazing by animals such as camels, goats and donkeys occurred near this area. Vegetation is very sparse; runoff water from the area seeps into underground aquifers used for stock water and, in In Ekker, some 5 km distant, for drinking water. Another In Ekker site — Adrar Tikertine experimentation site — where the Pollen experiments caused the dispersion of

² Gerboise Bleue, 1960 - Reggane, French Algeria. Atomic Archive, <https://www.atomicarchive.com/media/photographs/testing/french/gerboise_bleue-1.html/, accessed 12 February 2025>.

³ Robert S. Norris, Thomas B. Cochrany, "France in 'nuclear weapon' in 'The spread of nuclear weapons'", Britannica, https://www.britannica.com/technology/nuclear-weapon/France/, accessed 12 February 2025>.

⁴ "Radiological conditions at the former French nuclear test sites in Algeria : preliminary assessment and recommendations, International Atomic Energy Agency", 2005, <https://www.iaea.org/publications/7174/ radiological-conditions-at-the-former-french-nuclear-test-sites-in-algeria-preliminary-assessment-and-recommendations/, accessed 12 February 2025>.

⁵ Algeria Cities by Population 2024, World Population Review, 2024, https://worldpopulationreview.com/cities/ algeria/, accessed 12 February 2025>.

plutonium in fine particulate form, the situation with vegetation, runoff water, and grazing animals was pretty much the same as near Taourirt Tan Afella.

The mission found that, in case these areas remain as uninhabited as in 1999, radiological doses were not over minimum safety standards. According to the assessment, environmental remediation of any test areas to reduce doses below established safety standards was not required. IAEA experts claimed, "However, future decisions by the Algerian authorities to conduct remediation or to limit public access might be made if economic conditions change in the area and a more permanent presence of people is indicated".⁶

Algeria's Efforts to Address the Legacy of Nuclear Testing

Although practical remediation efforts were initially limited due to political and economic obstacles in the first decades following independence, Algeria has implemented various measures to address these issues. These actions reflect both national initiatives and efforts to engage with international frameworks aimed at supporting victims and addressing the consequences of nuclear testing:

Legal and Diplomatic Actions

Algeria has engaged in diplomatic efforts to compel France to declassify documents and disclose information about nuclear waste burial sites, including detailed maps of contaminated areas and burial sites for nuclear waste.⁷ Algeria has also pursued legal actions, including filing lawsuits against France. This legal action was part of ongoing efforts to address health and environmental damages caused by these tests.⁸

Support for Compensation Frameworks

The Algerian government has emphasized the necessity of providing compensation for victims of French nuclear testing, acknowledging the substantial impacts of these tests on individuals and communities.⁹ Algeria has engaged in discussions regarding compensation frameworks to promote fair treatment for those affected. The French government finally enacted "Law No. 2010-2 of January 5, 2010, on the Recognition and Compensation of Victims of French Nuclear Tests" (commonly called the "Morin Law" (Loi Morin)¹⁰ to offer compensation to individuals impacted by nuclear tests;¹¹ however, it has faced criticism for

⁶ "Radiological conditions at the former French nuclear test sites in Algeria : preliminary assessment and recommendations, International Atomic Energy Agency", 2005, <https://www.iaea.org/publications/7174/ radiological-conditions-at-the-former-french-nuclear-test-sites-in-algeria-preliminary-assessment-and-recommendations/, accessed 12 February 2025>.

⁷ Shoaa, "International Day Against Nuclear Tests: The Nuclear Test File in Algeria - A Radioactive Legacy with Lasting Catastrophic Effects", 29 August 2024, https://shoaa.org/international-day-against-nuclear-test-the-nuclear-test-file-in-algeria-a-radioactive-legacy-with-lasting-catastrophic-effects/, accessed 12 February 2025>.

⁸ In 2017, The Algerian League for the Defense of Human Rights has filed a lawsuit against France regarding the nuclear tests conducted during its occupation of Algeria.

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⁹ Shoaa for Human Rights, Letter about the French nuclear tests in Algeria on the occasion of the International Day against Nuclear Tests," 29 August 2023, https://shoaa.org/?p=4579/, accessed 12 February 2025>.

¹⁰ The Morin Law primarily addresses French citizens and may exclude many Algerians who were directly impacted by nuclear testing in their homeland, which raises concerns about equity and justice. As a result, the Algerian government has been vocal in advocating for reforms to broaden the scope of this law or create new frameworks that are inclusive of its citizens. This includes calls for France to take responsibility for its colonial past and provide reparations for the environmental and health damage inflicted upon the Algerian populace.

¹¹ BBC News. "France's Nuclear Tests in Algeria: The Untold Story." Last modified 6 April 2021, <https://www.bbc. com/news/world-africa-56799670/, accessed 12 February 2025>.

its limited applicability, particularly regarding Algerian victims, indicating the need for more inclusive reparative measures.¹²

International Advocacy

Algeria has actively sought international support for its nuclear test victims while promoting the ratification of the TPNW. In addition to advocating for compensation, the government engages with human rights organizations and international bodies to raise awareness of the unique circumstances faced by Algerian victims and to pressure France to address these injustices. At various international forums, Algeria has pushed for recognition of victims' rights and urged other nations to provide technical and financial assistance to affected populations.¹³ By ratifying the TPNW, which obligates states to assist victims and engage in environmental remediation, Algeria aims to strengthen its advocacy for victims' support and to highlight its commitment to global disarmament efforts.¹⁴

Collaboration with International Organizations

Algeria has sought assistance from international bodies such as the International Atomic Energy Agency (IAEA) to assess radiological conditions at former test sites. These assessments are critical for understanding the ongoing risks to public health and the environment.¹⁵

Establishment of Agencies and Promotion of Civil Society Involvement

In 2021, Algeria formed the "National Agency for the Rehabilitation of French Nuclear Test Sites",¹⁶ tasked with overseeing the assessment and rehabilitation of contaminated sites.¹⁷ This effort was complemented by encouraging civil society organizations focused on environmental rights and victim advocacy, which are crucial in raising awareness and ensuring governmental accountability.¹⁸ However, the agency's reports are not publicly accessible, and the results of its efforts remain unknown to the public.

Health Assessments and Support

Algeria has initiated health assessments to evaluate the long-term effects of nuclear testing on local populations. This includes monitoring health conditions related to radiation ex-

¹² Toshiki Mashimo, French Compensation System for Victims of Nuclear Tests: The Battle over the Presumption of Causality, CPHU Research Report Series, Issue 35, (2022): 70.

¹³ Anadolu Agency. "Impact of France's Nuclear Tests Persists in Algeria," 14 February 2021, <https://www.aa.com. tr/en/africa/impact-of-frances-nuclear-tests-persists-algeria/2143751/, accessed 12 February 2025>.

¹⁴ International Campaign to Abolish Nuclear Weapons. "Algeria," https://www.icanw.org/algeria/, accessed 12 February 2025>.

¹⁵ International Atomic Energy Agency. Evaluation of the Effectiveness of the International Atomic Energy Agency's Technical Cooperation Program. Vienna: IAEA, 2005, https://www-pub.iaea.org/MTCD/Publications/ PDF/Publ215_web_new.pdf/, accessed 12 February 2025>.

او كالة الأنباء الجزائرية ،و كالة الأنباء الجزائرية، خبراء فرنسيون يشنون إنشاء الوكالة الوطنية لإعادة تأهيل المواقع القديمة للتجارب النووية في الجزائر its organization and functions. The agency is responsible for implementing rehabilitation programs for these sites, managing related contracts, and coordinating training for personnel. It may seek national or international technical assistance and must obtain prior approval for the acceptance of rehabilitated structures. Additionally, it can act as a delegated project owner for executing rehabilitation activities on behalf of the state.

لمين ص، إنشاء وكالة وطنية لإعادة تأهيل المواقع القديمة للتجارب والتفجيرات النووية الفرنسية في الجنوب الجزائري https://tinyurl.com/ sc4y876n/, accessed 12 February 2025>.

ت المرافع القديمة للتجارب النووية في الجزائر، وكالة الأنباء الجزائرية، 17 وكالة الأنباء الجزائرية، 18 الأنباء الجزائرية، 17 وكالة الأنباء الجزائرية، 17 وكالة الأنباء الجزائرية، 18 وكالة الأنباء الجزائرية، 19 وكالة المواقع القديمة للتجارب النووية في الجزائر، وكالة الأنباء الجزائرية، 18 وكالة الأنباء الجزائرية، 18 وكالة ا

Asharq Al-Awsat, Int'l Organizations Condemn France's 'Silence' Over Nuclear Waste Sites in Algeria,
 February 2024, <a href="https://english.aawsat.com/arab-world/4853381-intl-organizations-condemn-frances-%E2%80%98silence%E2%80%99-over-nuclear-waste-sites-algeria?_wrapper_format=html&page=1/, accessed
 February 2025>.

posure and providing medical support where possible.¹⁹ Simultaneously, the government and civil society organizations have conducted public health campaigns to raise awareness about radiation exposure risks, educating local populations on potential health issues such as increased cancer rates and congenital deformities.²⁰

Despite the establishment of the National Agency for the Rehabilitation of Former French Nuclear Test Sites, the actual rehabilitation of affected cities and sites in Algeria remains largely unfulfilled. Reports indicate that France has not undertaken substantial initiatives to clean up contaminated areas or provide adequate compensation to victims. This lack of action is compounded by a significant transparency issue, as detailed information regarding the locations of radioactive waste burial sites is not readily available. Such opacity complicates remediation efforts and hinders progress in addressing the long-term impacts of nuclear testing.²¹

The effectiveness of the agency's efforts is further obscured by the absence of detailed reports and outcomes related to their rehabilitation initiatives. As a result, it remains unclear how much progress has been made in rehabilitating the affected regions. The ongoing involvement of civil society organizations is crucial in this context, as these groups advocate for environmental rights and highlight the pressing issues faced by impacted communities. Their efforts promote accountability and ensure that the voices of those affected are heard, emphasizing the need for comprehensive support and remediation measures to address their needs effectively.

KAZAKHSTAN'S NUCLEAR LEGACIES: SITES, IMPACTS, AND RESPONSES

In the 40 years between 1949 and 1989, the Soviet government conducted around 456 nuclear weapons test explosions — 64% of all USSR nuclear tests — or equivalent to approximately 2,500 Hiroshima atomic bombs²² at the Semipalatinsk Nuclear Test Site (STS) at the intersection of three regions of Northeastern Kazakhstan: Pavlodar, Karagandy, and Abay (formerly Semey region) and part of East Kazakhstan region.²³ STS was the world's largest nuclear weapons testing ground, spanning 18,311.4 km²; in comparison, the State of Qatar is 11,500 km², and the Kingdom of Belgium is 30,000 km²,²⁴ impacting around 1.5 million humans

¹⁹ BBC, "France-Algeria relations: The lingering fallout from nuclear tests in the Sahara," 27 April 2021, <https:// www.bbc.com/news/world-africa-56799670/, accessed 12 February 2025>.

²⁰ Abdul Razzaq Bin Abdullah, Impact of France's nuclear tests persists: Algeria, 2021,

<https://www.aa.com.tr/en/africa/impact-of-frances-nuclear-tests-persists-algeria/2143751/, accessed 12 February 2025>.

²¹ France 24. "France's 1960s Nuclear Tests in Algeria Still Poison Ties." 29 July 2021, https://www.france24.com/en/live-news/20210729-france-s-1960s-nuclear-tests-in-algeria-still-poison-ties/, accessed 12 February 2025>.

²² United Nations General Assembly, "Report of the Secretary-General on Sustainable Development: International Cooperation and Coordination for the Human and Ecological Rehabilitation and Economic Development of the Semipalatinsk Region of Kazakhstan", 16 August 2023, https://documents.un.org/doc/undoc/gen/n23/242/47/ pdf/n2324247.pdf/, accessed 11 February 2025>.

²³ Government of Kazakhstan, "Report of Kazakhstan to the Second Meeting of States Parties to the Treaty on the Prohibition of Nuclear Weapons", 21 November 2023, <https://docs-library.unoda.org/Treaty_on_the_ Prohibition_of_Nuclear_Weapons_-SecondMeeting_of_States_Parties_(2023)/TPNW.MSP_.2023.10_Kazakhstan_ report_advanced_unedited.pdf/, accessed 10 February 2025>.

and their descendants²² up until the 3rd and 4th generations,²⁵ thus forming the largest nuclear-affected community globally. Notably, the explosions included both atmospheric and underground explosions, with notable events at the STS such as the USSR's first nuclear bomb test, codenamed "First Lightning," (1949) of 22 kilotons (kt) of TNT as well as the RDS-6 – first aerial thermonuclear bomb test (1953) of 400 kt of TNT.

The nuclear frontline communities absorbed a cumulative effective dose averaging 634 mSv, which is substantially higher than the average annual exposure of about four mSv for Kazakh citizens due to natural background radiation, including additional sources such as medical procedures. This indicates a severe public health crisis stemming from decades of nuclear testing.²⁶ High rates of cancer-related illnesses are observed in industrially developed regions and areas near the former STS. In the Abay Region, the primary causes of death are diseases of the circulatory system, followed by cancers. Specifically, 25.3% of deaths in this region are due to circulatory system diseases, which is higher than the national average (22.3%). Additionally, 13.3% of deaths are attributed to cancers, significantly exceeding the national average (9.7%).²⁷

Additionally, PNEs conducted outside military test sites occurred twice in the South Kazakhstan region and once in each of the Aktobe, Akmola, Kostanay, and West Kazakhstan regions. These detonations aimed to conduct deep seismic prospecting to reveal underground structures and explore natural resources. All of them happened from 1971 to 1973 except the one in the Aktobe region in 1987, which was the most profound and strongest explosion.

The examination of nuclear test sites utilized for "peaceful" purposes reveals a complex interplay between the sites themselves and the associated projects or experiments. These sites were not merely locations for testing but were integral to ambitious initiatives aimed at harnessing nuclear technology for non-military applications. The International Atomic Energy Agency (IAEA) has conducted study visits to these sites; however, there still needs to be more comprehensive reviews and analyses of these visits. Addressing this gap is essential for understanding the implications of PNEs and their long-term impacts on both the environment and public health.

Conversion of Former Semipalatinsk Nuclear Test Site (STS)

The elimination program of nuclear infrastructure at the STS is part of a Kazakhstan-USA Intergovernmental Agreement under the 1992 Cooperative Threat Reduction (CTR) Program, also known as the Nunn-Lugar Program, aimed to assist Kazakhstan, alongside the Russian Federation, Ukraine, and Belarus, in dismantling Soviet-era strategic offensive nuclear weapons systems and destructing and decontaminating the military infrastructure and facilities following Kazakhstan's independence in 1991.²⁸ This program also created an export

²⁵ Togzhan Kassenova, "How Kazakhstan Fought Back Against Soviet Nuclear Tests", Carnegie Endowment for International Peace, 14 February 2022, <https://carnegieendowment.org/posts/2022/02/how-kazakhstan-foughtback-against-soviet-nuclear-tests?lang=en/, accessed 8 February 2025>.

²⁶ United Nations Economic Commission for Europe, "Environmental Performance Reviews: Kazakhstan", United Nations, n.d., 2000, <https://unece.org/DAM/env/epr/epr_studies/kazakhstan.pdf/, accessed 12 February 2025>.

²⁷ United Nations Secretary General, "Report of the Secretary-General on Sustainable Development: International Cooperation and Coordination for the Human and Ecological Rehabilitation and Economic Development of the Semipalatinsk Region of Kazakhstan", United Nations General Assembly, 16 August 2023, <https://documents.un.org/doc/undoc/gen/n23/242/47/pdf/n2324247.pdf/, accessed 5 February 2025>.

²⁸ National Nuclear Center of the Republic of Kazakhstan, "Nuclear Infrastructure Elimination Program", n.d., <https://www.nnc.kz/en/activity/sts.html/, accessed 2 February 2025>.

control system and improved the management and control of nuclear materials and the conversion of the defense industry.

Key milestones include:

 1993: USA and Kazakhstan signed a Joint Statement of Intent to assess the impact of Soviet nuclear testing.

• 1994: Project Sapphire was an operation to secure and transfer 600 kilograms of highly enriched uranium (HEU) from Kazakhstan to the U.S. as part of the CTR program, involving the U.S., Kazakhstan, and the IAEA to prevent nuclear proliferation.

• 1996: Kazakhstan designated the National Nuclear Center (NNC) as the central agency responsible for nuclear infrastructure elimination (now managing STS facilities, focusing on civilian usage and transitioning the site to non-defense applications).

 1996-2001: Closure of 181 tunnels in the Degelen Mountain Complex and 13 test holes at the Balapan Testing Field, with radio-ecological monitoring conducted by NNC specialists.

- 2000: Complete dismantlement of testing infrastructure at STS.
- 2020: Remnants of nuclear tests at the Experimental Field, where significant air and ground explosions occurred, were deemed secure.²⁹

Currently, the CTR program implements two programs in Kazakhstan: Global Nuclear Security (GNS) and the Biological Threat Reduction Program (BTRP). The GNS program builds partner capacity to secure nuclear material, safeguard vulnerable fissile material, and counter nuclear smuggling. The BTRP assists the government of Kazakhstan in enhancing biosafety and biosecurity procedures, diagnostic capabilities, and compliance with international health regulations.³⁰

The adoption of the TPNW has led to enhanced cooperation among Non-Nuclear Weapon States (NNWS) in addressing nuclear legacies, establishing a framework that prioritizes victim assistance, environmental remediation, and international cooperation.³¹ This framework is structured around key articles of the TPNW and its Vienna Action Plan, with two-thirds of action items focused on Articles 6 and 7, which address these above-mentioned critical areas. Since the 1st Meeting of States Parties (1MSP), four institutional types have been created within the TPNW framework: Informal Working Groups (IWGs), a Scientific Advisory Group (SAG), Focal Points, and Informal Facilitators, collectively organizing 62 activities,³² Notably,

²⁹ Government of Kazakhstan, "Assessments of the consequences of nuclear tests on the territory of Kazakhstan", Second Meeting of States Parties to the Treaty on the Prohibition of Nuclear Weapons, 21 November 2023, <https:// www.ohchr.org/sites/default/files/documents/issues/climatechange/cfis/cfi-nuclear-legacy/subm-addressingchallenes-barriers-sta-kazakhstan.pdf/, accessed 1 February 2025>.

³⁰ Bureau of South and Central Asian Affairs, "U.S. Relations With Kazakhstan", U.S. Department of State, 5 July 2023, <https://www.state.gov/u-s-relations-with-kazakhstan/, accessed 11 February 2025>.

³¹ United Nations Office for Disarmament Affairs, "Treaty on the Prohibition of Nuclear Weapons", United Nations, n.d., https://disarmament.unoda.org/wmd/nuclear/tpnw/, accessed 12 February 2025>.

³² International Campaign to Abolish Nuclear Weapons, "Intersessional Progress on the TPNW", n.d., <https:// www.icanw.org/tpnw_intersessional_work/, accessed 11 February 2025>.

the IWG on Articles 6 and 7 co-chaired by Kazakhstan and Kiribati has conducted 13 meetings, the highest among the groups formed. Despite these efforts, transparency in reporting outcomes and inclusion of all key stakeholders, especially the representatives of nuclear front-line communities and youth, remains a challenge. Additionally, on 12 October 2023, Kazakhstan co-sponsored the UNGA resolution³³ aimed at assessing ongoing needs related to victim assistance and environmental remediation, furthering discussions among TPNW stakeholders — including diplomats, scientists, and advocates — for evidence-based policy recommendations to inform the International Trust Fund (ITF) established for addressing these issues over the coming years.

CONCLUSION

The cases of Algeria and Kazakhstan underscore the enduring and multifaceted challenges posed by the legacy of nuclear testing. Decades after the last detonations, both nations continue to grapple with these programs' environmental, health, and socio-political consequences. Algeria's experience reflects the complexities of addressing post-colonial legacies, where historical power dynamics persist in influencing contemporary efforts at remediation and justice. The nation's ongoing efforts to secure transparency and reparations from France highlight the critical role of international accountability and the challenges of navigating historical grievances in the modern era. Kazakhstan offers a contrasting approach, marked by proactive international engagement and a focus on dismantling nuclear infrastructure. The nation has made substantial progress through initiatives such as the CTR program and establishing the Semipalatinsk Nuclear Safety Zone. However, the extensive environmental and public health damage remains a significant challenge, underscoring the need for sustained efforts in remediation, education, and community support.

Both cases illustrate the broader implications of nuclear testing, extending beyond national boundaries to encompass issues of global governance, environmental stewardship, and human rights. They highlight the necessity of transparency, international cooperation, and comprehensive frameworks for victim assistance and environmental remediation. Future efforts must address unresolved challenges, such as the lack of detailed data on contamination in Algeria and the need for further public engagement and equitable resource distribution in Kazakhstan. These experiences also serve as a call for greater international accountability in addressing the long-term consequences of nuclear weapons testing. Efforts such as the Treaty on the Prohibition of Nuclear Weapons provide a framework for collective action, emphasizing victim assistance and environmental restoration. Algeria's advocacy for transparency and Kazakhstan's leadership in international nuclear non-proliferation initiatives underscore the potential of affected nations to shape the global discourse on nuclear justice.

Finally, it would be worth stressing that while the CTBT does not directly address the complicated issues of nuclear legacy resulting from nuclear testing, the fact that it resolutely outlaws such testing provides a substantial boost and point of reference to the actions of governments and the public in this area. Furthermore, the sooner the treaty enters into force, the sooner the non-testing legal norm will be consolidated and universally recognized as a part of international law, thus offering crucial additional cover to much-needed post-nuclear remediation and restoration activities.

³³ Ivaylo Gatev, "Sustainable Development: Report of the Second Committee.", United Nations General Assembly Second Comittiee, 7 December 2023, https://documents.un.org/doc/undoc/gen/n23/394/93/pdf/n2339493.pdf/, accessed 8 February 2025>.

Nuclear-Weapon-Free Zones and the CTBT: How Can the Two Nuclear Disarmament Mechanisms Reinforce Each Other?

- Kudakwashe Mapako Emily Puisseaux Moreno
- Elisa Shafiqah Shahrilnizam Karolina Velichkova

ABSTRACT

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) and Nuclear-Weapon-Free Zones (NWFZs) are foundational pillars of nuclear non-proliferation and disarmament. The CTBT envisages a global ban on nuclear testing while NWFZs establish regional prohibitions on nuclear weapon development and deployment. This paper explores the mutually reinforcing roles of the CTBT and NWFZs, highlighting how their combined legal frameworks, verification mechanisms, and diplomatic advocacy bolster global and regional security. The CTBT's verification system, including the International Monitoring System and On-Site Inspections, can enhance NWFZs' capacity to monitor compliance, building a robust detection network. However, operational and geopolitical challenges, particularly in regions like the Middle East, Europe and South Asia, limit these mechanisms' full potential. The analysis concludes with recommendations for expanding CTBT-NWFZs cooperation through capacity-building, new NWFZs initiatives and advocacy for future CTBT entry into force, aiming to strengthen the global nuclear disarmament regime.

INTRODUCTION

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) and Nuclear-Weapon-Free Zones (NWFZs) are key pillars of global nuclear disarmament and non-proliferation. While the CTBT seeks a universal ban on nuclear testing, NWFZs establish region-specific prohibitions on nuclear weapons. Despite differing scopes, their objectives intersect, reinforcing legal commitments, enhancing verification, and promoting regional security. This paper explores how the CTBT and NWFZs complement each other, strengthening global efforts to prevent nuclear proliferation and achieve disarmament, while addressing the geopolitical challenges that hinder their full potential.

UNDERSTANDING COMPREHENSIVE NUCLEAR-TEST-BAN TREATY (CTBT)

The CTBT serves as a cornerstone of global nuclear security, reinforcing existing legal frameworks and providing a path toward nuclear disarmament.¹ With 178 states that have

¹ Lassina Zerbo, "Advancing Nuclear Disarmament through the CTBT", New Zealand International Review, 2019, <https://www.jstor.org/stable/48552181/, accessed 27 September 2024>. John D. Holum, "The CTBT and Nuclear Disarmament. The U.S. View", Journal of International Affairs, 1997, <http://www.jstor.org/stable/24357483/, accessed 7 February 2025>.
NUCLEAR-WEAPON-FREE ZONES AND THE CTBT: HOW CAN THE TWO NUCLEAR DISARMAMENT MECHANISMS REINFORCE EACH OTHER?

ratified the CTBT,² the Treaty is promoting a norm against nuclear testing, reinforcing Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The CTBT is not yet in force due to the lack of ratification by all Annex 2 countries,³ which is delaying full implementation of its verification provisions. Once in force, the global monitoring system will effectively meet the treaty's verification goals.⁴

The CTBT will be monitored through various means — (1) the National Technical Means (NTMs) of various countries, (2) the International Monitoring System (IMS) negotiated under the CTBT that consists of seismic, hydroacoustic, radionuclide, and infrasound⁵ networks all over the world to monitor for nuclear tests explosions,⁶ along with (3) On-Site Inspections (OSI) once the CTBT enters into force,⁷ in order to look for evidence on the ground.⁸ These components are currently addressed by the Provisional Technical Secretariat of the Preparatory Commission for the CTBTO. In addition, the CTBT verification regime includes a mechanism based on Consultation and Clarification and Confidence-Building Measures.⁹ Data from the IMS worldwide is already being processed and distributed to member states through the International Data Center (IDC). The sharing of technical data and the participation in OSI exercises are signs of positive cooperation generated by the Treaty.

The relationship between the CTBT and other non-proliferation legal frameworks is crucial to further strengthen barriers against hypothetical transgressions of not just the nuclear test ban but of other regimes as well. This can be achieved by consolidating legal synergies, the complementarity of their verification mechanisms, amplifying diplomatic advocacy through the NWFZs to support the CTBT's objectives, and fostering technical cooperation between both types of instruments to enhance their capacity-building. As data collection increases and global communication networks develop through regional and other partnerships, the CTBT monitoring capabilities will also strengthen.¹⁰

UNDERSTANDING NUCLEAR-WEAPON-FREE ZONES (NWFZS)

Establishment of NWFZs is recognized as an instrument contributing to security of respective member states, to the prevention of proliferation of nuclear weapons and to the goals of

² CTBTO [@CTBTO], "#DYK 29 August is the International Day against Nuclear Tests?", X, 7 August 2024, <https://x. com/CTBTO/status/1821078826505662831?t=mYOcKAKky6p8GnffT97pGA&s=08/, accessed 7 February 2025>.

³ Annex II states that have not ratified: China, the Democratic People's Republic of Korea or North Korea, Egypt, the United States, India, Iran, Israel, Pakistan, and Russia since 2023.

⁴ Mao Sato, "Advancing Nuclear Test Verification without Entry into Force of the CTBT", Journal for Peace and Nuclear Disarmament, 2021, https://doi.org/10.1080/25751654.2021.1993643, accessed 7 February 2025>.

⁵ Keith A. Hansen, "The Comprehensive Nuclear Test Ban Treaty: An Insider's Perspective", Stanford University Press, 2006.

⁶ The International Monitoring System has matured considerably. Taking into account recent figures, by November 2024, the total of installed stations is 301 (93.8% of 321) of which 292 are certified (91.0%).

⁷ The Seismological Society of America (SSA) and the American Geophysical Union (AGU), "The Capability to Monitor the Comprehensive Nuclear-Test-Ban Treaty (CTBT) Should be Expanded, Completed, and Sustained. SSA-AGU Updated Position on Comprehensive Nuclear-Test Ban Treaty", April 2022, <https://www.agu.org/-/media/ files/share-and-advocate-for-science/position-statements/the-capability-to-monitor-the-comprehensivenuclear-test-ban-treaty-should-be-expanded-completed-and.pdf/, accessed 7 February 2025>.

⁸ On-site exercises are already underway to prepare for the day the CTBT enters into force.

⁹ CTBTO Preparatory Commission, "Overview of the verification regime", 2024, <https://www.ctbto.org/ourwork/verification-regime/, accessed 7 February 2025>.

¹⁰ The Seismological Society of America (SSA) and the American Geophysical Union (AGU), "The Capability to Monitor the Comprehensive Nuclear-Test-Ban Treaty (CTBT) Should be Expanded, Completed, and Sustained. SSA-AGU Updated Position on Comprehensive Nuclear-Test Ban Treaty", April 2022, <https://www.agu.org/-/media/ files/share-and-advocate-for-science/position-statements/the-capability-to-monitor-the-comprehensivenuclear-test-ban-treaty-should-be-expanded-completed-and.pdf/, accessed 5 February 2025>.

general and complete disarmament by Article VII of the NPT¹¹ and by United Nations General Assembly Resolution 3472. NWFZs treaties create legally binding agreements that prohibit nuclear weapon development, possession, testing, use, production, or acquisition, along with any assistance or encouragement related to such actions within designated areas.¹²

Nevertheless, an argument can be made that the NWFZs agreements may strengthen, in certain way, positions of some states that claim a legitimate right to own nuclear arms.¹³ To begin with, these protocols strengthen the position of certain states that claim a legitimate right to own nuclear arms. By permitting/inviting these states to enter agreements that rule out the use of such weapons against member of a given NWFZ as well as stationing of their nuclear weapons within the zone (even in the territories they may possess there), the zonal agreements indirectly validate the right to possess nuclear weapons elsewhere and potentially use them against other targets.

Furthermore, although these zones ban nuclear arms, they may encompass countries like Australia (party to the Treaty of Rarotonga) which are allied with partners whose security policies may involve the potential use of nuclear weapons.¹⁴ More recently, this aspect has become even more complicated due to the concept of integrated deterrence, which presupposes much closer coordination of nuclear and non-nuclear forces of different nations in the prosecution of war. However, this raises inquiries regarding the terminology of the agreements and whether these regional instruments encompass comprehensive legal obligations to some of their members.

By integrating NWFZs into an international legal regime, a structure would be established that enables any individual state to join in the legal rejection of nuclear weapons, even if its neighbors are not prepared to follow suit. The acknowledgement of Mongolia as a single-state NWFZ illustrates this possibility. Since NWFZs have garnered widespread acclaim for their contribution to global security, an international instrument based on this foundation would likely face minimal coherent criticism. In short, NWFZs have garnered widespread acclaim for their contribution to global security, effectively reinforcing CTBT provisions.¹⁵

¹¹ The Treaty on the Non-Proliferation of Nuclear Weapons, Article VII, 1968, <https://treaties.un.org/pages/ showDetails.aspx?objid=08000002801d56c5, accessed February 7, 2025>.

¹² Maya Brehm, Richard Moyes, and Thomas Nash, "Banning Nuclear Weapons", Article 36, February 2013, <https://article36.org/wp-content/uploads/2013/02/Report_web_23.02.13.pdf/, accessed 7 February 2025>.

¹³ Maya Brehm, Richard Moyes, and Thomas Nash, "Banning Nuclear Weapons", Article 36, February 2013, <https://article36.org/wp-content/uploads/2013/02/Report_web_23.02.13.pdf/, accessed 7 February 2025>.

¹⁴ Although Australia is a signatory to the Treaty of Rarotonga, it has made it clear that it will depend on the US' nuclear deterrent for its defense. Consequently, Australia finds itself in a challenging position, as it is a member of the South Pacific NWFZ and would be expected to possibly engage in a nuclear strike as it is allied with a nuclear-armed state at the same time. Australian Government, "2017 Foreign Policy White Paper", November 2017, https://www.dfat.gov.au/sites/default/files/2017-foreign-policy-white-paper.pdf/, accessed 7 February 2025>. LtCol Brent Stricker, "Containing the Bomb: An Assessment of Nuclear Weapons Free Zones", Center for International Maritime Security, 12 April 2023, https://cimsec.org/containing-the-bomb-an-assessment-of-nuclear-weapons-free-zones/, accessed 7 February 2025>.

¹⁵ The case of the Arab Republic of Egypt is one of interest considering that it has signed both the Pelindaba Treaty and the CTBT but has ratified neither of them. Egypt has withheld ratification of the CTBT, insisting on an equitable approach that includes Israel's ratification of both the CTBT and NPT. Egypt has expressed a willingness to ratify the CTBT, but this is contingent on tangible, practical steps that enhance the credibility of Israel's pledge toward a nuclear-free Middle East. Nabil Fahmy, "Nuclear Non-Proliferation and Disarmament in the Middle East", Journal for Peace and Nuclear Disarmament, 2022, <https://doi.org/10.1080/25751654.2022.2078140/, accessed 7 February 2025>.

MEANS & CHALLENGES OF REINFORCEMENT FOR CTBT AND NWFZS

Legal Synergies and Norm Building

The legal frameworks of NWFZs and the CTBT share a fundamental goal: preventing nuclear proliferation and testing. Together, they form a layered international legal structure that bolsters both regional and global non-proliferation efforts. All existing NWFZs explicitly prohibit nuclear testing within their territories, aligning with the CTBT's global mandate. This overlap creates dual obligations for state parties to both treaties, reinforcing norms against testing. The Treaty of Tlatelolco in Latin America, which predates the CTBT, served as a precedent by embedding non-testing commitments, inspiring subsequent NWFZs.¹⁶

Legal alignment between the CTBT and NWFZs creates a mutually reinforcing framework where regional commitments support global non-proliferation efforts. The Treaty of Pelindaba incorporates non-testing provisions consistent with the CTBT, strengthening Africa's unified stance against nuclear testing.¹⁷ Similarly, the Treaty of Rarotonga in the South Pacific leverages the CTBT's verification infrastructure, such as seismic and infrasound monitoring, to enhance compliance and security. These legal and verification synergies encourage NWFZ states to ratify the CTBT and work hard to ensure its earliest entry into force. Ratifying the CTBT allows states to demonstrate the non-military intent of their nuclear activities and enables nuclear-armed states to signal readiness for meaningful constraints. Advancing universal adoption and enforcement of the CTBT strengthens existing NWFZs and encourages the creation of new ones.

However, regions without NWFZs such as the Middle East, South Asia, and Europe pose challenges to global nuclear non-proliferation. In the Middle East, the lack of a NWFZ leaves the region vulnerable to nuclear development, particularly with Israel's ambiguous nuclear policy and refusal to ratify the CTBT.¹⁸ Efforts to establish a Middle East NWFZ (MENWFZ) face obstacles due to geopolitical tensions, complex alliances, and regional rivalries.¹⁹ In South Asia, the absence of a NWFZ complicates non-proliferation, as India and Pakistan maintain active nuclear arsenals and rely (in one way or another) on nuclear deterrence.²⁰ Meanwhile, in Europe, NATO's self-proclamation as a "nuclear alliance", strategies based on "extended nuclear deterrence", especially nuclear-sharing arrangements, are in conflict with the principles of NWFZs and weaken the influence of global disarmament frameworks.²¹ Expanding NWFZs to these regions is a crucial diplomatic goal. Establishing such zones

¹⁶ A. Gautam, "Regional nuclear disarmament and non-proliferation: a case of canwfz treaty", International Studies, 2024, <https://doi.org/10.1177/00208817241228720/, accessed 7 February 2025>.

¹⁷ M. Hamel-Green, "Nuclear deadlock, stalled diplomacy: the northeast Asia nuclear weapon-free zone alternative–proposals, pathways, prospects", Journal for Peace and Nuclear Disarmament, 2021, <https://doi.org/1 0.1080/25751654.2021.1875285/, accessed 7 February 2025>.

¹⁸ According to the Stockholm International Peace Research Institute (SIPRI), Israel is considered a Nuclear-Weapon State with a stockpile of approximately 90 nuclear weapons. Stockholm International Peace Research Institute, "SIPRI Yearbook 2024. Armaments, Disarmament and International Security", 2024, http://bit.ly/3MXEGZQ/, accessed 7 February 2025>.

¹⁹ A. Ellner, "British nuclear non-proliferation policies towards Iran and the Middle East", Review of International Affairs, 2013, https://doi.org/10.1080/09557571.2012.734780, accessed 7 February 2025>.

²⁰ A. Pietrobon, "Nuclear powers' disarmament obligation under the treaty on the non-proliferation of nuclear weapons and the comprehensive nuclear test ban treaty: interactions between soft law and hard law", Leiden Journal of International Law, 2013, https://doi.org/10.1017/s0922156513000587, accessed 7 February 2025>.

²¹ According to the United Nations Office for Disarmament Affairs' criteria, there are 4 regional approaches towards creating peace and security, including regional and sub-regional organizations, confidence- and security-building measures, NWFZs and Zones of Peace.

would create new legal synergies with the CTBT, strengthen non-proliferation obligations, and reinforce efforts to achieve a universally nuclear-free world.

Verification Mechanisms and Compliance Enhancement

Verification and compliance are essential components of both the CTBT and NWFZs, with mechanisms that mutually reinforce each other. The CTBT's IMS, OSI, and IDC provide a global verification infrastructure that strengthens NWFZs' ability to better sustain their regional nuclear test bans. Together, these systems create a multi-tiered verification framework that enhances both regional and global confidence and compliance.

Firstly, the IMS covers all five NWFZs regions, offering near real-time data that supports regional monitoring. Secondly, once the CTBT enters into force, the OSI will add a critical layer of verification for NWFZs.²² The OSI will enable NWFZs members to address suspicious activities by leveraging the CTBT's global resources, reinforcing regional and global disarmament goals. In addition, the IDC processes data from IMS stations worldwide, providing centralized, accurate information that NWFZs rely on to monitor nuclear activity. This centralized data analysis by the IDC strengthens transparency and decision-making, enabling NWFZs to act on credible information and reinforce trust in their commitments.

Regional Security Dynamics and Diplomatic Advocacy

NWFZs not only bolster regional security but also serve as platforms for diplomatic activity that support the CTBT's objectives. By creating nuclear-weapon-free regions, NWFZs reduce the risk of nuclear conflict and advance global disarmament goals. The effectiveness of NWFZs in stabilizing regions demonstrates their power to enhance both regional and global security through collective agreements prohibiting nuclear weapons and testing. For example, the Treaty of Tlatelolco was instrumental in preventing nuclear proliferation in Latin America during the Cold War, reinforcing regional stability and contributing to global non-proliferation efforts.²³ Similarly, the Treaty of Rarotonga in the South Pacific has somewhat safeguarded a geopolitically sensitive area from nuclear threats.²⁴ These NWFZs not only uphold regional security by preventing nuclear escalation but also complement the CTBT's global mandate to eliminate nuclear testing.

In addition, NWFZs provide platforms for diplomacy in support of the CTBT ratification and implementation. For instance, the Treaty of Pelindaba has enabled African states to champion the CTBT in international forums, urging universal ratification and heightened compliance in regions where nuclear testing is still a concern.²⁵

²² D. Adašková, & T. Ludík, "The comprehensive nuclear-test-ban treaty and its relevance for global security", Obrana a Strategie (Defence & Strategy), 2013, <https://doi.org/10.3849/1802-7199.13.2013.01.047-058/, accessed 7 February 2025>.

²³ M. Hamel-Green, "Nuclear deadlock, stalled diplomacy: the northeast Asia nuclear weapon-free zone alternative–proposals, pathways, prospects", Journal for Peace and Nuclear Disarmament, 2021, https://doi.org/10.1080/25751654.2021.1875285, accessed 7 February 2025>.

²⁴ A. Gautam, "Regional nuclear disarmament and non-proliferation: a case of canwfz treaty", International Studies, 2024, <https://doi.org/10.1177/00208817241228720/, accessed 7 February 2025>.

²⁵ M. Hamel-Green, "Nuclear deadlock, stalled diplomacy: the northeast Asia nuclear weapon-free zone alternative–proposals, pathways, prospects", Journal for Peace and Nuclear Disarmament, 2021, https://doi.org/1 0.1080/25751654.2021.1875285/, accessed 7 February 2025>.

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Capacity-Building and Technical Cooperation

Capacity-building and technical cooperation are vital for enabling NWFZs to effectively monitor and ensure sustainability of their nuclear-free commitments. While NWFZs establish regional frameworks for disarmament, many member states lack the technical resources and funding to develop independent verification systems. The CTBT's IDC offers training and technical support to NWFZs member states, improving their capacity to monitor nuclear activities. For instance, the Treaty of Pelindaba in Africa has benefited from CTBT capacity-building programs, training local scientists to interpret IMS data and integrate it into regional monitoring systems.²⁶

Additionally, the CTBT supports technical cooperation by providing access to its IMS. This collaboration is essential for regions like the South Pacific, where vast ocean territories pose monitoring challenges. This access to IMS data strengthens the region's ability to enforce its nuclear-free commitments, directly supporting the CTBT's broader mandate. IMS data allows Southeast Asian states to detect potential nuclear activities near their borders, supporting compliance with the Treaty's non-testing provisions.²⁷ This partnership enhances the regional security framework, ensuring Southeast Asia remains a nuclear-free zone amid complex geopolitical pressures. The CTBT's capacity-building programs remain instrumental in helping NWFZs achieve nuclear-free objectives. By providing technical expertise, training, and monitoring data to its signatories states, the CTBT enhances NWFZ verification capabilities, while reinforcing regional commitments to disarmament.

FURTHER NUANCES OF THE CTBT AND NWFZS NEXUS

CTBT as a Catalyst for a Middle East Nuclear-Weapon-Free Zone (or Zone Free of WMD)

The CTBT offers essential mechanisms to advance the long-standing goal of establishing a MENWFZ. Since the endorsement of a MENWFZ by the UNGA in 1974 (A/RES/50/66), progress has stalled. Given the region's current security challenges and diplomatic deadlocks, the CTBT's verification system can foster confidence-building measures, enhance transparency, and dispel misinformation. For instance, the CTBT's IMS was instrumental in clarifying the nature of seismic events in Iran, defusing tensions and providing assurances to neighboring countries like Israel. Universal ratification of the CTBT by Middle Eastern states would create a security environment conducive to pursuing a MENWFZ. Establishing a legally binding commitment to ban nuclear tests in the region is a foundational step toward broader non-proliferation goals. The CTBT offers low political risk and high benefits in trust-building, stability, and fostering the necessary groundwork for lasting regional security. The above applies to the initiative to establish a Middle-Eastern Zone, free of all WMD, approved by the NPT Review and Extension Conference in 1995, because the nuclear-weapon-free status of the region is supposed be part and parcel of that zone.

EXISTING SHORTCOMINGS IN THE NEXUS OF CTBT AND NWFZS

Financial Limitations

Despite the benefits, financial constraints remain a significant barrier to fully implementing CTBT verification systems in some regions. While it is true that the OSI segment will not

²⁶ O. Dahlman, "How can science support a process towards a world free of nuclear weapons?", Science and Global Security, 2013, https://doi.org/10.1080/08929882.2013.798980, accessed 7 February 2025>.

²⁷ L. Kokaji, & N. Shinohara, "Radiochemical verification technologies for the detection of nuclear explosionsrecent developments in radionuclide monitoring with the comprehensive nuclear-test-ban treaty", Journal of Nuclear and Radiochemical Sciences, 2014, https://doi.org/10.14494/jnrs.14.rl/, accessed 7 February 2025>.

be activated before the entry into force, the IMS segment is mostly operational, and will continue to need resources for maintenance, training, capacity building, not to mention running costs. Furthermore, there are suggestions aimed at ensuring its modernization to keep up with advances in science and technology. At the same time, some voices express concerns, questioning the necessity of investing in the IMS in the absence of the treaty's entry into force. These challenges underscore the need for sustained investment in local verification systems to ensure long-term effectiveness of capacity-building initiatives. It would be much easier to achieve if solid progress towards the CTBT's entry into force could be demonstrated.

Political Will vis-a-vis Capacity Building

The CTBT's capacity-building efforts are limited within the purview of the Treaty as far as its obligations to state parties are concerned. It is not within the mandate of the CTBTO (currently, the Preparatory Commission) to offer capacity-building cooperation with the NWFZs as regional blocks, instead, it aids state parties upon their requests.²⁸ Political instability also impacts capacity-building, particularly in regions with internal conflicts or limited political commitment to disarmament. For example, the Treaty of Semipalatinsk in Central Asia faces obstacles related to resource allocation and regional cooperation, which limits its ability to fully benefit from CTBT assistance.

Apart from the capacity deficit that is present in majority of the developing states in NWFZs, there is a lack of prioritization and urgency to develop nuclear test detection capacity and ratify the CTBT, as these states are facing more pressing immediate challenges such as healthcare, poverty, and infrastructure development among other concerns.²⁹

Conflicting commitment of NWFZs States vis-à-vis the CTBT

Among all NWFZs States, Egypt, as a leading signatory of the Pelindaba Treaty, has only signed and not ratified the CTBT. The status of Egypt's proposed IMS stations remains as "planned" not "certified". This divergence in Egypt's approach raises questions, as its role as a signatory to the Pelindaba Treaty suggests a strong commitment to non-proliferation. Advancing toward ratification of the CTBT and completing its segment of the IMS would further demonstrate its leadership in regional and global disarmament efforts. However, Egypt's political and security considerations are complex. As noted, Egypt has been a key proponent of a Nuclear-Weapon-Free Zone in the Middle East while also sharing a border with Israel, a state widely believed to possess nuclear capabilities but that has not formally acknowledged them or committed to disarmament. This intricate geopolitical landscape presents challenges to advancing progress on multiple fronts simultaneously.

RECOMMENDATION FOR MORE CTBT-NWFZS MUTUAL REINFORCEMENT

• Enhance cooperation between the Provisional Technical Secretariat with NWFZs by highlighting their complementary objectives and areas where they can derive potential benefits.

²⁸ The Comprehensive Nuclear-Test-Ban Treaty, Article II (A) (5) and Article III (4), 1996, <https://www.ctbto.org/ our-mission/the-treaty/, accessed 7 February 2025>.

²⁹ J. L. Black-Branch, "The Treaty Prohibiting Nuclear Weapons: Legal Challenges for Military Doctrines and Deterrence Policies", Cambridge University Press, 2021.

• Participate in specific meetings within the NWFZs frameworks where the PTS can increase awareness and capacity-building efforts, bearing in mind NWFZs particular security landscape and challenges impeding their more active participation.

• Actively promote the universalization of the CTBT in the Middle East as a prerequisite for building the necessary foundation for a Nuclear Weapons Test Free Zone and a WMD-Free Zone.

• NWFZs Member States should leverage their regional proximity to states not parties to CTBT and their understanding of the security dynamics in specific zones to propose policy options, including the CTBT ratification by members of the NWFZs not parties to the CTBT without compromising the state' security interests.

CONCLUSION

In conclusion, the CTBT and NWFZs are vital tools for global nuclear disarmament and nonproliferation. Their legal synergies, verification mechanisms, and regional security benefits reinforce commitments to end nuclear testing and curb proliferation. However, geopolitical tensions, financial limitations, and regional disparities hinder their full potential, especially in the Middle East, South Asia, and Europe. Diplomacy, advocacy, capacity-building, and expanding NWFZs are key to advancing a nuclear-free world.

ANNEX

Table 1. Status of the Installation and Certification Programme for Primary and Auxiliary Seismic, Hydroacoustic, Infrasound and Radionuclide Stations as of 30 June 2024³⁰

IMS STATION TYPE	INSTALLATION COMPLETE		UNDER	CONTRACT	
	CERTIFIED	NOT CERTIFIED	CONSTRUCTION	NEGOTIATION	NOTSTARTED
Primary seismic	45	1	_	1	3
Auxiliary seismic	110	7		_	3
Hydroacoustic	11	_	_		
Infrasound	53	1	1		5
Radionuclide	73			2	5
Total	292	9	1	3	16

³⁰ CTBTO Preparatory Commission, "Report of the Executive Secretary on verification related activities for the period January-June 2024" (p. 5), 26 July 2024.

Table 2. Table on NWFZs key provisions³¹

TREATY	STATUS	PROHIBITIONS
Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Treaty of Tlatelolco)	Signed: 14 Feb 1967 Effective: 22 Apr 1968 Parties: 33 Duration: indefinite	No testing, use, manufacture, production, acquisition, receipt, storage, installation, deployment, possession of any nuclear weapons. No engaging in, authorizing or encouraging of the above.
South Pacific Nuclear- Weapon-Free Zone Treaty (Treaty of Rarotonga)	Signed: 6 Aug 1985 Effective: 11 Dec 1986 Parties: 13 Duration: indefinite	No testing, manufacture, acquisition, possession, control, stationing of any nuclear explosive device. No dumping and storage of radioactive matter. No provision of fissionable material unless safeguarded by the NPT or the International Atomic Energy Agency (IAEA). No seeking or receiving assistance and no encouraging of the above.
Treaty of the Southeast Asia Nuclear-Weapon-Free Zone (Treaty of Bangkok)	Signed: 15 Dec 1995 Effective: 28 Mar 1997 Parties: 10 Duration: indefinite	No testing, use, development, manufacture, acquisition, possession, control, stationing, transport of nuclear weapons. No dumping/discharging/disposing and storage of radioactive matter. No provision of fissionable material unless safeguarded by the NPT or IAEA. No seeking or receiving assistance and no encouraging of the above.
African Nuclear-Weapon- Free Zone Treaty (Treaty of Pelindaba)	Signed: 11 Apr 1996 Effective: 15 Jul 2009 Parties: 43 Duration: indefinite	No testing, research on, development, manufacture, stockpile, acquisition, possession, control, stationing of any nuclear explosive device. No dumping and storage of radioactive matter. No provision of fissionable material unless safeguarded by the IAEA. No armed attack on nuclear installations. No seeking or receiving assistance and no encouraging of the above.
Treaty on a Nuclear-Weapon- Free Zone in Central Asia (Treaty of Semipalatinsk)	Signed: 8 Sep 2006 Effective: 21 Mar 2009 Parties: 5 Duration: indefinite	No testing, use, research on, development, manufacture, stockpile, acquisition, possession, control, stationing, storage, receipt, installation of any nuclear explosive device. No provision of fissionable material unless safeguarded by the IAEA. No seeking or receiving assistance and no encouraging of the above.
Law of Mongolia on its Nuclear-Weapon-Free Status	Signed: 25 Sep 1992 Effective: 3 Feb 2000 Parties: 1 Duration: indefinite	No testing, use, development, manufacture, acquisition, possession, control, station, transportation of nuclear weapons or nuclear parts or components. No dumping/disposing and transportation of radioactive matter.

PROTOCOL	STATUS	CHINA	FRANCE	RUSSIAN FEDERATION	UNITED KINGDOM	UNITED STATES
Additional Protocol II to the Treaty of Tlatelolco	Signed Ratified	21 Aug. 1973 12 June 1974	18 July 1973 22 Mar. 1974	18 May 1978 8 Jan. 1979	20 Dec. 1967 11 Dec. 1969	1 Apr. 1968 12 May 1971
Protocol II to the Treaty of Rarotonga	Signed Ratified	10 Feb. 1987 21 Oct. 1988	25 Mar. 1996 20 Sep. 1996	15 Dec. 1986 21 Apr. 1988	25 Mar. 1996 19 Sep. 1997	25 Mar. 1996 -
Protocol to the Bangkok Treaty	Signed Ratified		-	-	-	
Protocol I to the Pelindaba Treaty	Signed Ratified	11 Apr. 1996 10 Oct. 1997	11 Apr. 1996 20 Sep. 1996	5 Nov 1996 5 Apr. 2011	11 Apr. 1996 12 Mar. 2001	11 Apr. 1996 -
Protocol to the Semipalatinsk Treaty	Signed Ratified	6 May 2014 17 Aug. 2015	6 May 2014 17 Nov. 2014	6 May 2014 22 Jun. 2015	6 May 2014 30 Jan. 2015	6 May 2014 -

Table 3. Status of ratification of the protocols to the treaties establishing NWFZs as of 2025³²

³² United Nations Office for Disarmament Affairs, "Nuclear-Weapon-Free Zones", United Nations, https://www.un.org/nwfz/, accessed 7 February 2025>.

The Role of New Generation Experts in Promoting the CTBT and Facilitating its Entry into Force

■ Prince Amoah ■ Hely Desai ■ Ahyousha Khan ■ Kokoro Nishiyama

ABSTRACT

The current rise in geopolitical tensions and actual armed conflicts, as well as re-invigorated debate on the use of nuclear arms and renewal of the nuclear arms calls for concerted efforts from all fronts for the entry into force (EIF) of the CTBT. This paper explores the critical role of new-generation experts in advancing the Comprehensive Nuclear-Test-Ban Treaty (CTBT) and promoting its entry into force. Despite broad international support since its adoption in 1996, the CTBT remains unratified by nine key states, delaying its legal enactment. Young professionals, empowered by initiatives like the CTBTO Youth Group (CYG) and supported by United Nations policies, are uniquely positioned to contribute to this mission through technical expertise, innovative advocacy, and diplomacy. This paper discusses how young experts can leverage digital platforms, scientific diplomacy, and cross-border partnerships to build momentum for CTBT ratification and secure a future free from nuclear testing.

INTRODUCTION

The Comprehensive Nuclear-Test-Ban Treaty (CTBT), adopted by the United Nations General Assembly in 1996, aims to outlaw nuclear testing for both civilian and military purposes. A total of 178 countries have signed and ratified the CTBT, 8 countries have signed but not ratified it, 1 country has withdrawn its ratification, and 9 countries have not signed the treaty. Notably, nine states—China, Egypt, India, Iran, Israel, the Democratic People's Republic of Korea (DPRK), Pakistan, the United States, and Russia (after the latter's recent withdrawal of its ratification) — continue to make the key requirement for the EIF unfulfilled. Shaping the next generation's perspective towards nuclear weapons and nuclear testing will be key in the effective elaboration of relevant treaties, their ratification and full implementation.

There are 1.9 billion adolescents and youth aged 10-24,¹ and as the declaration on the commemoration of the seventy-fifth anniversary of the United Nations (A/RES/75/1) states, "Youth is the missing piece for peace and development". Young people around the world have a critical role to play in raising awareness and developing new ways to reduce threats from weapons of mass destruction and conventional arms, including their proliferation.²

¹ "Call to Action: Prioritizing What Young People Want For a Sustainable Post-2030 Era", World Health Organization, 2024, https://pmnch.who.int/docs/librariesprovider9/meeting-reports/nb---prioritizing-what-young-people-want-for-a-sustainable-post-2030-era.pdf, accessed 11 March 2025>.

² "Disarmament and Youth", United Nations Office for Disarmament Affairs, <https://disarmament.unoda.org/ disarmament-and-youth/, accessed 11 March 2025>.

THE ROLE OF NEW GENERATION EXPERTS IN PROMOTING THE CTBT AND FACILITATING ITS ENTRY INTO FORCE

The United Nations Secretary-General António Guterres in his policy brief on the New Agenda for Peace, noted that "youth are essential to identifying new solutions that will secure the breakthroughs that our world urgently needs". Similarly, the UN Youth Strategy underscores that meaningful engagement with youth and enabling their active participation are essential for achieving global peace, security, and sustainable development.³

The UN General Assembly reaffirmed the important and positive contribution that young people can make in sustaining peace and security through its unanimous support of the biennial resolution entitled "Youth, disarmament and non-proliferation," adopted on 12 December 2019 74/64⁴ and 6 December 2021, 76/45.⁵ Through its adoption, Member States, the United Nations, relevant specialized agencies, and regional and sub-regional organizations are encouraged to promote the meaningful and inclusive participation of young people in discussions in the field of disarmament and non-proliferation.

If we apply the above considerations more specifically to the CTBT, we should also take note of the fact that the treaty was negotiated mainly in 1994-1995, but that the final rush to the agreed text had been preceded by more than 30 years of scientific and diplomatic work, both in multilateral and more narrow formats, which produced a number of outcomes. Many senior negotiators and advisers who remembered many intricacies and details about why certain issues had been resolved in a particular way and why certain approaches had been dropped, are no longer with us or are in retirement. The same applies many outstanding individuals who had been contributing to the elaboration of the CTBT while wearing NGO or academic hats. This is not a trivial issue, because the lack of good knowledge about the past might lead to mistakes and wrong conclusions about the present and future issues. This is not to say that that next generations should be prisoners of the past, but becoming prisoners of ignorance is not helpful either. At the same time younger generations have an advantage of being able to look at issues from new angles and to apply innovative approaches and methodologies.

APPROACHES TO EXPLORE

1. Innovative Advocacy Strategies

Young experts are adept at utilizing digital platforms and social media to spread awareness and engage a global audience on important issues. By leveraging their familiarity with digital tools, they can advocate for the CTBT's entry into force:

• Influence through Gamification: Youth are highly engaged with interactive content. Developing educational games or applications about CTBT and its importance could be a creative way to raise awareness while educating younger audiences in an engaging manner. This would be an inclusive initiative since there are no language barriers. For example, the tool such as a NUKEMAP⁶ simulation has the potential to intuitively convey the threat of nuclear weapons and the importance of the CTBT.

³ Ibid.

⁴ "Youth, disarmament and non-proliferation : resolution / adopted by the General Assembly", A/RES/76/45, United Nations Digital Library, 2021, <https://digitallibrary.un.org/record/3951436?v=pdf/, accessed 11 March 2025>.

⁵ "Resolution adopted by the General Assembly on 12 December 2019", A/RES/74/64, United Nations Official Document System, 2019, <https://documents.un.org/doc/undoc/gen/n19/416/02/pdf/n1941602.pdf/, accessed 11 March 2025>.

^{6 &}quot;NUKEMAP by Alex Wellerstein, <https://nuclearsecrecy.com/nukemap/, accessed 11 March 2025>.

Users can set the location and power of nuclear explosions, experiencing first-hand the human and environmental devastation. The game also educates players about the long-term societal impacts of nuclear tests and explores the risks of not ratifying the CTBT. Through interactive choices, the game highlights the significance of supporting the CTBT and the need for actions toward nuclear disarmament. Targeted at younger generations and educational institutions, this tool raises awareness of the realities of nuclear weapons and promotes the importance of preventing nuclear testing. A note of caution, though: one should be aware of risks involved in using simulation games, such as the same NUKEMAP, which may be seen as a tool for simplification of issues of grave importance for the humankind, like nuclear war, turning them into a game. Therefore, a possibility of designing custom-made games focused on nuclear testing should be explored.

• Social Media Campaigns: By using platforms like Twitter, Instagram, and YouTube, young advocates can spread information about the dangers of nuclear testing and the benefits of the CTBT. Hashtags, short videos, and interactive posts can generate attention and mobilize support. #MeToo and #BlackLivesMatter are well-known movements derived from and exploiting hashtags. These have not only sparked great online controversy but also raised awareness of the issues over the shadows and resulted in citizens' willingness to act together to change a particular situation or narrative. Per CTBT, we suggest mobilising hashtags like #YouthAgainstNUCLEARTesting.

Brand Ambassador: Appoint a well-known advocate in the field or beyond, to connect with youth and enhance engagement. One example is Emma Watson, a UN Women Goodwill Ambassador, who established the "HeForShe campaign" to involve men and boys in the fight for women's rights and gender equality.⁷ Emma Watson, known for her leading roles in famous films, is a well-recognized figure among young people. By having a well-known and youth-recognized figure as the face of a campaign, it is believed that the movement gains strength. Using this phenomenon as an example, appointing a brand ambassador for the CTBTO could have positive effects, such as increasing awareness of the CTBT.

• Creating Educational Content: Young professionals can produce easy-to-understand educational materials, including podcasts, videos, and webinars, to simplify the treaty's technical aspects for the general public and policymakers. If effective content can be created in conjunction with the use of social media, it would be effective in increasing awareness of the CTBT.

• Art and Culture as Tools for Engagement: Encourage young filmmakers and artists to produce documentaries and art projects highlighting the dangers of nuclear testing per se and in a wider context of reducing nuclear risks and preventing nuclear war. Art Exhibitions and Performances, utilizing art and cultural expressions to communicate concerns about nuclear weapons and testing.

2. Technical Expertise in Treaty Verification

The CTBT's International Monitoring System (IMS) plays a central role in verifying compliance by detecting nuclear tests. New-generation experts in fields like physics, seismology, ecology and data science can make significant contributions by improving verification processes:

⁷ "UN Women Goodwill Ambassador Emma Watson", UN Women, <https://www.unwomen.org/en/partnerships/goodwill-ambassadors/emma-watson/, accessed 11 March 2025>.

• Improving Data Analysis: The application of advanced technologies such as machine learning, artificial intelligence (AI), and big data analytics can enhance the efficiency and accuracy of IMS data analysis, improving the detection of nuclear tests.

• Strengthening On-Site Inspections: Experts can contribute to the development of new inspection techniques and technologies, bolstering the ability to investigate suspected treaty violations, while reminding the audience that the full potential of this method can only be achieved through the EIF of the CTBT.

• Promoting "Scientific Youth" Diplomacy: Young professionals can engage in scientific diplomacy, using technical expertise to build bridges with states that have not yet ratified the treaty. Collaborative research projects and technical exchanges can open diplomatic dialogues, offering avenues for constructive discussions on nuclear arms control, nonproliferation and disarmament.

• Leveraging Al-enabled Chatbots: We are heading towards the age of Al, where Alpowered chatbots offer a dynamic and innovative tool to promote the CTBT, particularly in the states that have not yet signed or ratified the treaty. These chatbots can serve as real-time Q&A platforms, addressing frequently asked questions about the CTBT's history, purpose, and benefits while debunking myths or misinformation that often hinder arms control efforts. For instance, in countries like the United States or Egypt, chatbots could provide factual yet diplomatic explanations for their non-ratification and direct users to resources that emphasize the treaty's relevance. Chatbots can also feature localized content tailored to specific audiences, highlighting how ratification aligns with national goals, such as regional stability for India or Pakistan. These chatbots can also facilitate digital petitions and pledge sign-ups, creating grassroots pressure on policymakers by demonstrating public support for ratification. Language localization and accessibility ensure a broader global reach, enabling users to engage in their native languages. For example, Arabic-speaking audiences could be informed about how ratification supports Middle Eastern peace and security. In addition, chatbots could notify users about upcoming CTBTO webinars, regional forums, or high-level events, encouraging participation and fostering dialogue. Seamless integration across social media platforms like Facebook Messenger, Instagram, WhatsApp, and Twitter/X enhances accessibility, allowing users to engage through simple hashtags or direct messages.

• Public Relations and Strategic Communication: Experts with a background in communication can craft compelling narratives around nuclear non-proliferation, highlighting the humanitarian, environmental, and security advantages of the CTBT.

3. Diplomatic and Policy Engagement

Youth engagement in diplomacy and policy-making is crucial for the future of the CTBT. As emerging leaders in international relations, new-generation experts can contribute significantly to treaty promotion through:

• Lobbying for Ratification: Young diplomats and policy experts can work with governments, international organizations, and civil society groups to lobby for the ratification of the CTBT in non-signatory (non-ratifying) states. They can also assist in influencing political leaders in states that are key to the treaty's entry into force.

• Multilateral Dialogues and Track II Diplomacy: New-generation experts can facilitate informal, Track II dialogues involving experts, diplomats, and civil society from both ratifying and non-ratifying countries. These dialogues can create a more constructive environment for addressing concerns and overcoming political deadlock.

• Youth-Led Diplomacy: Young professionals can participate in youth delegations at United Nations forums and regional organizations to push forward the CTBT agenda, ensuring the inclusion of youth perspectives in international discussions on disarmament and nuclear non-proliferation. In parallel, states signatories can be recommended to consider inclusion of young professionals or even graduation students as interns into their respective delegations to meetings and conferences dealing with the nuclear test ban and related subjects.

• University-level Education: Signatory states should be advised to encourage relevant universities to promote courses, preparation of papers by students and facilitate interuniversity events devoted to the nuclear test ban and related issues, with particular attention being paid to nurturing interdisciplinary forms of engagement (i.e. bringing together students in political affairs, law, science, communication, etc).

4. Fostering International Cooperation

Building global partnerships and networks is essential for advancing the CTBT. The new generation of experts can play a crucial role in creating cross-border collaborations:

• **Clobal Partnerships:** Young professionals can help connect governments, international organizations, and academic institutions to build networks focused on both the technical and political aspects of the CTBT.

• Collaborative Research Projects: Engaging in joint research projects between universities, think tanks and technical organizations can advance the CTBT's verification regime.

• Expert Networks: Initiatives like the CTBTO Youth Group (CYG) provide young professionals with a platform to collaborate on promoting the CTBT and to advocate for its universalization and entry into force.

5. Leading Public and Scientific Diplomacy

Youth involvement in scientific advocacy can further strengthen the case for the CTBT. Newgeneration experts with scientific backgrounds can present evidence about the health, environmental, and security consequences of nuclear testing:

• Scientific Advocacy: Experts can publish research, articles, and op-eds to highlight the environmental, health, and security impacts of nuclear testing. They can use this research to make a compelling case for the CTBT and demonstrate its importance in safeguarding global peace.

• Engaging Civil Society: By working with NGOs and civil society organizations, young experts can help bridge the gap between science and policy, ensuring both the public and decision-makers understand the significance of the CTBT.

• International Conferences: Young professionals can actively participate in international conferences like the CTBTO Science and Technology Conferences or the NPT Review

Conferences to raise awareness about the CTBT, present research, and network with policymakers.

6. Engaging in Capacity-Building Initiatives

The new generation can also play an important role in building the technical expertise necessary to implement and monitor the CTBT:

• Training and Capacity-Building: By providing training workshops and educational programs, young professionals can help build local expertise in treaty monitoring and verification. This ensures that more states can contribute to the CTBTO's verification regime, strengthening its global reach.

• Outreach Lecture: Organising outreach lectures and visiting educational institutions such as universities and graduate schools to deliver guest lectures. Such direct engagement can inspire the younger generation by providing the CTBT content with firsthand insights into the CTBT's objectives and challenges. Exposure to these lectures may motivate students to pursue careers related to nuclear disarmament and non-proliferation, potentially sparking innovative approaches to advancing the Treaty's entry into force.

7. The importance of preserving traditional knowledge and methodologies on the CTBT

The above suggestions have been designed in order to maximize potential advantages that could be brought to the field by new generations of experts. However, their introduction should not be detrimental to the task of keeping the wealth of traditional knowledge and skills relating to nuclear testing and to the CTBT in particular.

CONCLUSION

The role of the new generation of experts is indispensable in promoting the CTBT and facilitating its entry into force. With their technical expertise, innovative advocacy strategies, and diplomatic engagement, young professionals can help break the current deadlock in treaty ratification. By harnessing the power of digital platforms, scientific diplomacy, and international cooperation, the youth can generate the momentum needed to ensure the CTBT's widespread adoption. Their engagement in the process of putting an end to nuclear testing, alongside continued efforts to educate the public and policymakers, is essential to achieving a world free of nuclear tests and to securing a safer, more sustainable future for all.

INITIATIVE	DESCRIPTION	TARGET OUTCOME	
Social Media Campaigns	Use platforms like X/Twitter, Instagram, and YouTube to raise awareness of the CTBT and its importance.	Increase global awareness and public support for the CTBT's entry into force.	
Educational Initiatives	Offer scholarships, fellowships, and courses related to nuclear non- proliferation and disarmament.	Build a new generation of experts equipped to contribute to treaty monitoring and policy discussions.	
Youth-Led Advocacy	Form youth delegations and grassroots campaigns advocating for CTBT ratification.	Mobilize youth to push governments towards ratifying the CTBT.	
Hackathons for Peace (Gamification)	Host innovation challenges and more gamification initiatives focused on developing new technologies for CTBT verification.	Inspire the next generation of scientists and technologists to contribute to the CTBTO's monitoring systems.	

PROPOSED INITIATIVES FOR YOUTH ENGAGEMENT:

By empowering youth, governments, NGOs, and international organizations can ensure that the momentum for CTBT entry into force continues, fostering a world that prioritizes peace and security over nuclear proliferation.