CBWNet

Strengthening the norms against chemical and biological weapons

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Workshop on S&T developments with relevance for the CWC and the BWC

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Abbreviations

- BWC/BTWC: Biological Weapons Convention /Biological and Toxin Weapons Convention
- CTBT: Comprehensive Nuclear-Test-Ban Treaty
- CTBTO: Comprehensive Nuclear-Test-Ban Treaty Organisation
- CWC: Chemical Weapons Convention
- DAT: Declaration Assessment Team
- FFM: Fact-finding Mission
- IAEA: International Atomic Energy Agency
- IATA: International Air Transport Association
- IIT: Investigation and Identification Team
- INFCIRC: Information Circulars
- JIM: Joint Investigative Mechanism
- NPT: Treaty on the Non-Proliferation of Nuclear Weapons
- OPCW: Organisation for the Prohibition of Chemical Weapons
- OSI: Open Source Information
- PNE: Peaceful Nuclear Explosions
- SAB: Scientific advisory board
- SAGSI: Standing Advisory Group on Safeguards Implementation
- S&T: Science and Technology
- UNSGM: United Nations Secretary-General's Mechanism
- WMD: weapons of mass destruction

Introduction to the Workshop – The Role of S&T in the BWC and the CWC Regimes

Gunnar Jeremias, ZNF, University of Hamburg and CBWNet

You have in front of you the compendium of contributions from the recent workshop organized by the CBWnet project (cbwnet.org), held on June 17th and 18th, 2024, at Hamburg University. This workshop brought together a diverse group of experts from fields such as biological and chemical arms control, life sciences, political science, and diplomacy. Participants represented a range of institutions, including academia and policy-making bodies, fostering a rich dialogue on the pressing challenges and opportunities facing biological and chemical arms control today.

A central theme of the workshop was the need for both the Biological Weapons Convention (BWC) and the Chemical Weapons Convention (CWC) to react to recent advancements in science and technology. The general purpose criterion that guides these treaties ensures that they remain relevant and effective in light of new developments. However, this requires a proactive approach to ensure that both the scientific community and policymakers are informed about the latest trends and challenges in their respective domains.

The discussions highlighted the intricate relationship between technological progress and arms control policy. As innovations emerge, they raise critical questions about how existing treaties can adapt and remain robust. Participants examined various concepts that could bridge the technical and political dimensions in this field of arms control, ensuring that treaty regimes are not only reactive but also anticipatory in their responses to scientific advancements.

Throughout the workshop, four panels delved into key topics: the general concept and application of scientific and technological advice in arms control in general and particularly in chemical and biological arms control; current developments in science and technology that may necessitate attention; potential frameworks for organizing verification under the CWC and the prospects for institution building for S&T advice and verification within the BWC; and the technologies and governance methods that could be employed to enhance the efficacy of arms control measures.

The insights gathered during these discussions aim to contribute to the ongoing discourse on arms control, ensuring that both the BWC and CWC remain vital in a landscape marked by rapid scientific change. This compendium encapsulates the collaborative efforts and perspectives of workshop participants, reflecting a shared commitment to advancing arms control in an increasingly complex world.

The Role of S&T Advice in Arms Control and Disarmament Treaties

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1. Science and technology (S&T) underpins all of the multilateral arms control and disarmament WMD treaties, whether in the shape of the specified monitoring technologies used in the CTBT, or the dual-use nature of the science and technology in the BTWC and CWC contexts. For this reason, issues of technological change bring both benefits and threats to the continued relevance and effectiveness of the treaties. There has been a range of different approaches to rendering and providing S&T advice, some large, others small, or some combination of both, as we can see in the history of the NPT/IAEA, BTWC, CWC, and CTBT.

2. The IAEA's Director General established a Standing Advisory Group on Safeguards Implementation (SAGSI) in 1975 four years after the agreement on the INFCIRC/153 comprehensive safeguards system implementing NPT's Article III. Its aims include considering and providing advice on technical objectives and implementation parameters of safeguards, particularly to assure their continued validity given changing technical circumstances. The IAEA also ran five expert Panels on Peaceful Nuclear Explosions (PNE) between 1970 and 1975 to look at the technical aspects of PNEs and how they might be used in fulfillment of the NPT's Article V. At a much larger scale there was International Nuclear Fuel Cycle Evaluation 1977-1979 that looked at whether there was a proliferation-resistant fuel cycle. This provided an eight-volume report of its findings.

3. The UK and others looked to SAGSI during the CWC negotiations as a possible model for an advisory function in a future Convention. France made proposals for a Scientific Advisory Board in 1987 and 1989, which were essentially adopted in the Convention's Article VIII. These noted that S&T progress would inevitably occur, and an advisory process would be needed to ensure the continued relevance of the verification regime. Once the CWC's SAB had been established and its work began, it became clear that the range of relevant scientific disciplines needed was too great for a small board of 20 or so experts to cover. This led to the creation of a series of Temporary Working Groups and workshops to draw on external expert advice from subject matter experts on discrete topics such as investigative science and technology.

4. In the BTWC context, the Ad Hoc Group of Government Experts (VEREX) was a large-scale state party-wide effort to identify and examine potential verification measures from a scientific and technical standpoint. This ran for two years and led ultimately to the Ad Hoc Group 1995-2001. Dedicated sessions on S&T topics have been held at the BTWC intersessional meetings since 2012. Arguments continue over whether a future BTWC process should be large-scale (open to all), small-scale (nominated experts), or some hybrid approach.

5. The CTBT will have its own SAB, largely similar in concept to the CWC's, once the treaty enters into force. In the meantime, the CTBTO has held seven large-scale science and technology conferences since 2009 to examine developments in the monitoring technologies used in the Treaty's verification regime. It also organizes smaller events, such as workshops and expert meetings looking at discrete elements of the treaty's verification technologies; for example, a Hydroacoustic Workshop in 2024 will examine as one of its objectives technological advancements in marine engineering pertinent to the sustainability and improvement of the hydroacoustic component of the Treaty's International Monitoring System.

6. S&T advice can thus be mediated and provided via large, small, or a mixture of arrangements and structures as discussed here. Unfortunately, it is not possible to exclude politics and wider geopolitical issues completely from these deliberations. Nevertheless, these structures have provided much sound advice that helps keep the treaties relevant. The ability to react and respond promptly with appropriate action, such as amendment of treaties or state-level actions required by Executive Council Decisions, is always likely to be difficult and slow. S&T change will invariably bring implications for treaty verification – both good (better detection) & bad (cheating). It is, therefore, essential to keep S&T issues at the forefront of treaty implementation and through properly resourced and mandated bodies, and for states parties to be ready to act upon advice and recommendations.

Science &Technology Advice for the Biological Weapons Convention

Una Jakob, Peace Research Institute Frankfurt (PRIF)

Why does biological disarmament need advice on scientific and technological developments?

The prohibition of biological weapons is comprehensive, and the Biological Weapons Convention (BWC) codifies strong norms against biological weapons and covers any relevant S&T developments through the 'General Purpose Criterion'. However, there are several areas in which S&T developments pose challenges to the implementation of the BWC.

First, due to the dual-use character of much of biological research, the strong connection of biodefence with health-related research, and the significant role of intent in biological weapons programs, risk assessments, and potential verification activities require a good deal of interpretation. *Second*, relevant S&T developments occur at a rapid pace in biology, biochemistry, and other relevant fields of science, such as information technology (artificial intelligence) or engineering (additive manufacturing, robotics). *Third*, the knowledge and capacity to understand and exploit S&T developments is distributed unevenly across the world. *Fourth*, there is still a lack of awareness among scientists for the security implications of some of their work, and there is a need for enhanced awareness-raising and education. *Fifth*, there are considerable political challenges surrounding biological weapons disarmament and S&T developments: a) the wide geographical spread of relevant technologies, a growing body of research with dual-use potential and a widening stakeholder spectrum which all might facilitate access to BW-relevant knowledge and materials for state and non-state actors; b) biological-weapons related disinformation that, if unchecked and not countered, could contribute to the further deterioration of the international security climate; c) changes in strategies of warfare that might change the rationale for BW acquisition, e.g. for targeted or covert action or to exploit the fact that attribution and identification of biological weapons attacks are particularly challenging; d) on a more positive note, the renewed discussions about compliance with and verification of the BWC which would be much supported by a thorough and collective science-based identification of current risks and technological opportunities.

In all these areas, a systematic and continuous review and monitoring of relevant S&T developments and BWC-specific science advice could help to provide a sound scientific basis for assessments and decision-making, to put states parties on a more equal footing in terms of capacity and knowledge, to raise awareness of security aspects of some research activities, to recognize and mitigate related risks, and to exploit benefits and opportunities arising from relevant S&T advances.

How were S&T developments handled in the BWC framework in the past?

The review of S&T developments is contained in Article XII of the BWC as a task for the review conference, and the topic was included in the agendas of all nine BWC review conferences held so far. However, in practice, the S&T review mostly consisted of (very few) states parties' submitting S&T reports and the Implementation Support Unit providing background documents on the issue. No systematic collective review of the reported developments ever took place. Interest in S&T review increased from 2011 onwards, when states parties put the topic on the agenda of the intersessional meetings first in 2012-2015, and again in 2018-2020.

Towards an S&T review and advisory body?

The idea of a standing S&T review and advisory body gained traction in the BWC after 2018/2019, when several states parties submitted proposals to that end. These proposals differed considerably regarding the size and modalities of such a body, but all agreed that institutionalized S&T review and advice would be desirable for the BWC. This notion garnered wide, though not universal, support among BWC states parties. Through a series of informal consultations within and outside the BWC framework, positions converged around a 'hybrid model' combining an open-ended body open to experts from all states parties and a limited-sized body comprised of a smaller number of experts. At the 9th BWC Review Conference in 2022, states parties tasked the newly established BWC Working Group with developing an S&T review mechanism, ideally

before the end of 2025, but in time for the 10th Review Conference in 2027 at the latest. If the statements at the 9th Review Conference in 2022 are any indication, there is very wide support for a standing S&T body among BWC states parties, and while different views persist regarding the details, there also seems to be broad recognition that such a body would benefit all states parties, and willingness to work constructively to reach agreement. However, the overarching geostrategic situation, and particularly the strong tensions between Russia on one hand and the USA, Ukraine, and other states on the other, have already had serious repercussions in the BWC framework, and it is currently uncertain to what extent this might also jeopardize the chance to establish an S&T review and advisory body for the BWC.

Developments in Synthetic Biology that are relevant to BWC

Dan Sabatelli, German Association for Synthetic Biology (GASB)

Synthetic biology is an area of biotechnology that is undergoing a period of rapid development. Some of its tools and applications are clear examples of dual-use technologies that hold great potential for society, but also pose substantial threats. This talk looked at these developments from the perspective of impacts to the Biological Weapons Convention (BWC). Though there are many ongoing relevant developments, this talk focused on three areas that are particularly concerning.

First, the increased accessibility of biological engineering tools dramatically increases the capability of non-state actors and amateur scientists. The rise of artificial intelligence, specifically generative AI, makes formerly difficult techniques easier to find and learn than ever before. Additionally, these models could potentially assist a malicious actor with strategies to evade export controls or sequence screening. The hardware required for DNA synthesis is also in a state of active development, with capabilities increasing and prices decreasing exponentially. Services that provide custom DNA generation are even cheaper, with significant challenges to screening customer sequences. Though currently there are still substantial hurdles to synthesizing pathogens more dangerous than those available in nature, these developments are steadily lowering the bar and increasing risk.

Second, at the cutting edge, the capabilities of synthetic biology techniques are steadily increasing. Since the introduction of CRISPR/CaS9 as a DNA editing tool, multiple variations have been produced, incrementally improving versatility and precision. Additionally, software biological design tools, many of which are based on AI and machine learning advances, have also developed significantly. These two categories of technology are developing in tandem, each accelerating the other's increase in capability, making the possibility of engineering a pathogen even greater.

Third is the increasing challenge of attribution. As the tools become more capable, the ability to mask or intentionally misattribute future biological weapons is a legitimate concern. Enforcing the BWC is extremely difficult when there is no way to prove who is responsible for the production of an engineered biological weapon, especially when it becomes increasingly difficult to prove that a pathogen has actually been engineered at all.

Finally, the talk outlined the efforts of the German Association for Synthetic Biology biosecurity team to address these issues. The organization’s biosecurity vision is to create a dialogue between various stakeholders to spread awareness of these issues and search for ways to address them. Active networking is ongoing to establish links to relevant stakeholders in Germany and Europe, including players in academia, industry, politics, the military, and the general public. Education on biosecurity issues is another focus, for both the organization itself, as well as the stakeholders mentioned above. Finally, with these pieces, the organization plans to facilitate communications between stakeholders by creating forums where people from diverse backgrounds can actively discuss and debate these issues.

Ultimately, developments in these areas of synthetic biology are increasing biosecurity risks in general and in the context of the BWC. Only through active communication between all stakeholders can awareness be raised and solutions found to mitigate them.

Developments in Chemistry & Biology – Lessons from SPIEZ Convergence

Sophie Reiners, Center for Security Studies – ETH Zurich

Spiez Convergence is a biennial 3-day conference that takes place in Spiez, Switzerland, and is organized by Spiez Laboratory, the Swiss Federal Institute for NBC-Protection, with support from the Center for Security Studies (CSS) at ETH Zurich. It brings together academia, industry, and arms control experts to discuss emerging science and technology developments, their convergence, and how they may affect the regimes governing the prohibition of chemical and biological weapons. The conference series started in 2014 and has since evolved from the convergence of only biology and chemistry to the convergence of many life science disciplines with other fields such as engineering, artificial intelligence, or machine learning. Some key findings of the developments in science and technology, presented by expert speakers at Spiez Convergence in 2022, and their impact on the conventions are summarized below.

Peptides, whose size is between small molecules and larger biologicals such as DNA and proteins, can now be synthesized in a more sustainable and efficient way. Researchers are also working on producing biologically active peptides that can be administered orally. It has been shown that bicyclic peptides are stable enough to survive the gastrointestinal tract, in which peptides are usually degraded by proteases and low pH. Peptides that could be made systemically available and reach the bloodstream could raise concerns from an arms control perspective, because they may have potential as novel chemical agents.

Coordination cages, also referred to as "molecular flasks", are three-dimensional structures that can self-assemble in a solution of metal ions and organic ligands. They can "host" chemicals due to their geometry and modulate the chemical reactivity, e.g. catalyze a specific reaction. They could be of interest from an arms control perspective to detoxify toxic chemicals or for decontamination.

At Spiez Convergence in 2021, an experiment was presented in which researchers from a pharmaceutical company inverted their AI model normally used for **drug discovery,** and instead of reducing the toxicity, they aimed for the high toxicity of the generated molecules. In only 6 hours, the model could generate 40,000 molecules that have a toxicity similar to VX. The researchers did not assess whether the generated molecules are synthesizable and how to make them with retrosynthesis software. This has led to two topics explored in 2022, the **evolution of the chemical space** with generative models and the assessment of **retrosynthesis tools**. "De novo molecules" with designed properties can now be generated with generative models and retrosynthesis tools can propose synthetic pathways towards a target molecule, including possible precursors and reactions, although with certain limitations. From an arms control perspective, potential risks could emerge if, for example, the tool would lead to novel synthesis methods for chemical weapons or if it could circumvent controlled precursors.

Bacteriophage cocktails in the context of phage therapy, can be used as an alternative to antibiotics due to their ability to selectively kill bacteria. They can be engineered in a way that they harbor a CRISPR-Cas3 system, increasing the killing power of the phage. There is a possibility that phages could be genetically engineered to express toxic or harmful genes or to target for example the native microbiome.

Protein structure prediction models such as AlphaFold or RoseTTAFold are increasing in accuracy. In addition, other deep learning tools to design proteins "de novo" that are not yet found in nature are becoming available. With the **era of biological technology**, there is a rise of cloud labs and biofoundries that automate and accelerate the design cycle for synthetic biology construction.

New medical devices are emerging, such as **microarray patches,** which consist of microscopic needles that can be coated with a vaccine. Due to easier application and lower demands on the supply chain, these have potential as next-generation vaccine delivery tools.

The next Spiez Convergence will take place in September 2024 and will cover different topics ranging from the manufacturing of chemicals, artificial intelligence, and automation to precise editing and drug delivery.

S&T around Proteins. Challenges and Opportunities for the BWC and the CWC

Anna Krin, ZNF, University of Hamburg

Scientific discoveries and technological advances related to proteins and polypeptides have significant implications for the BWC and the CWC. Many known **biotoxins** belong to the group of proteins, such as e.g. ricin that is covered both by the BWC and the CWC. Recently, the Scientific Advisory Board's Temporary Working Group has published a Report containing a list of "nine biotoxins and biotoxin families with various properties that should be considered "most relevant" [original quotation marks] in the context of the OPCW"[1]. In addition to ricin, further proteinogenic biotoxins such as abrin, epsilon toxin, *C. botulinum* toxins, and *S. aureus* enterotoxins were included in the list together with organic molecules such as saxitoxin, aflatoxins, T-2 toxin, and tetrodotoxin due to their toxicity/activity, stability, historical cases of use, etc.

Bioregulators (peptides, or small proteins involved in maintaining homeostasis in the body) are often discussed regarding their misuse potential and the coverage by the BWC and the CWC. If present in abnormal amounts, bioregulators can cause severe effects on the organism.[2] Advances in enabling technologies such as nanotechnology are further fueling the discussion around the misuse potential of bioregulators since they "can be leveraged in the production of […] biotoxins and bioregulators with characteristics that render them more useful for carrying out a biochemical warfare attack"[3]. In this context, methods to make peptides orally available[4] are also significant (see also contribution from S. Reiners in this manuscript, p. 8).

Enzymes can be utilized to synthesize various chemical compounds, such as fine chemicals, materials, pharmaceuticals, but also toxic substances. This last aspect emphasizes the dual-use potential of enzymatic catalysis. However, the technology can also be applied to e.g. synthesize reference samples of chemical warfare agents (CWAs) such as organophosphorus compounds for verification purposes in a safer way, applying the principles of green chemistry.[5] Additionally, specific enzymes can be used to decontaminate different CWAs including soman, sarin, tabun, VX, etc.[5]

Close monitoring of progress in the field of protein design and engineering is advisable due to the aspects mentioned above. Proteins can be expressed in different systems including bacteria, yeast, fungi, insect- and mammalian cells, or even transgenic animals and plants. In addition, cell-free solutions for protein expression could offer several advantages, such as more controllable experimental conditions, simpler workflows, and faster processes compared to e.g. the cell culture method. The cell-free approach combined with digital microfluidics was recently incorporated into a benchtop protein prototyping system.[6] Several methods exist for protein engineering such as rational design, semi-rational design, directed evolution, de novo design, computational approach, etc. On the one hand, they can be used to e.g. improve stability, catalytic activity, enantioselectivity, or expression level of enzymes used in the detoxification of the CWAs. On the other hand, protein engineering can potentially be applied to enhance the toxicity of certain proteins.[7] Computational methods incorporating artificial intelligence (AI) approaches for predicting protein structures and properties have gained considerable interest, triggering a debate about whether proteins designed by AI could be used as bioweapons.[8] While AI approaches are undoubtedly powerful, they still require experimental validation of the computational prediction. In general, mechanistic design and modeling of biochemical pathways are limited due to the complexity of biological systems with many species involved and numerous reactions and interactions to consider.

[1] Analysis of Biotoxins. Report of the Scientific Advisory Board's Temporary Working Group, SAB/REP/1/ 23, April 2023.
[2] Nixdorff K., The Central Role of Nanotechnology in Targeted Delivery of Biological Agents: Implications for Biosecurity, Policy Paper 9, Biochemical Security 2030 Project (2015).
[3] OPCW. Report by the Director-General, RC-5/DG.1, p.28, 22. February 2023.
[4] Spiez Convergence, Report on the fifth conference, September 2022
[5] Silva V.B., Santos Y.H., Hellinger R. et al. Organophosphorus chemical security from a peaceful perspective: Sustainable practices in its synthesis, decontamination and detection. *Green Chem.,* 24, 585–613, (2022).
[6] Nuclera eProtein Discovery™ https://www.nuclera.com/system/ (accessed 2024).
[7] Jefferson C. Protein Engineering. In Tucker J, editor, Innovation, Dual Use, and Security: Managing the Risks of Emerging Biological and Chemical Technologies. Cambridge, MA: MIT Press. 2012.
[8] Callaway E. Could AI-designed proteins be weaponized? Scientists lay out safety guidelines. *Nature News*, 8. March 2024.

Resources and Challenges for Investigation under the United Nations Secretary-General's Mechanism

Ines Mergler, Robert Koch-Institute

The United Nations Secretary-General's Mechanism for the Investigation of Alleged Use of Biological, Chemical or Toxin Weapons (UNSGM) is the only international mechanism with the mandate to determine whether biological weapons have been used, for example in the case of an international armed conflict. As such it remains an essential element for the verification of biological weapons use in the absence of a verification protocol under the Biological Weapons Convention (BWC) and an implementing institution. With the mandate "to ascertain in an objective and scientific manner the facts of the matter"[9], the United Nations (UN) Secretary-General is authorized to dispatch an international team of experts for a fact-finding mission and assign selected laboratories for the analysis of collected samples. The experts will summarize their conclusions and the laboratory results in a report to the UN member states that can serve as a basis for further action of the international community.

Resources for this mechanism are not based on a standing capacity but depend on nominations to a roster of experts and laboratories. While there is a broad expertise available with currently 626 qualified experts, 83 expert consultants and 93 analytical laboratories on the roster[9], equal geographical representation remains a challenge that the United Nations Office for Disarmament Affairs (UNODA) aims to address via measures such as outreach activities in underrepresented regions like Latin America.[10] There is also no permanent stock of equipment for investigations, so supplies are provided by in-kind contributions and UN support. Any UNSGM investigation will follow the terms outlined in the so-called "Guidelines and Procedures" which determine the roles and duties of involved stakeholders and the procedures to be followed for verifying if a biological weapon has been disseminated.[11] Attribution is not explicitly part of the mandate but has been considered to be a possible aspect of the investigation.[12] The Guidelines and Procedures have been designed to be applicable for the broad range of scenarios of chemical, biological, and toxin weapons use and hence, they do not include standard operating procedures that regulate, for instance, the collection and processing of samples or interviewing.

Past fact-finding missions and simulation exercises have pointed to several challenges that an investigation under the UNSGM would likely need to face. While lessons learned from the UNSGM deployment in Syria in 2013 have led to established cooperation structures such as a UN internal task force and increased training opportunities for qualified experts on the UNSGM roster[13], a recent full-scale exercise in 2020/2022 to simulate a UNSGM investigation of biological weapons use demonstrated further opportunities to strengthen the mechanism. The evaluators of the exercise found that "the UNSGM is functional and fully operational"[14] but that capacities could be strengthened through the development of an equipment list and further guiding documents for the investigation, through establishing a better understanding of UN structures and procedures amongst qualified experts, and by providing further training opportunities for qualified experts in various areas. Changes in the training program have been made since, for example with the introduction of regular UN security training (SSAFE courses) and further skilled training courses on topics such as decontamination, IATA certification, biological crime scene management, and interviewing.[15]

Due to the slow progress of negotiations and long-standing issues around verification within the BWC, the UNSGM will likely remain a crucial tool for the investigation of biological weapons use. Strengthening the

[9] UNODA website, https://disarmament.unoda.org/wmd/secretary-general-mechanism/ (accessed 2024)
[10] UNODA (2022): UNSGM Newsletter 07/2022, p. 5. https://front.un-arm.org/wp-content/uploads/2022/07/UNSGM-issue4.pdf (accessed 2024)
[11] UN General Assembly Resolution A/45/57C. https://undocs.org/a/44/561 (accessed 2024)
[12] UNODA (2015): The Secretary-General's Mechanism for Investigation of Alleged Use of Chemical, Bacteriological (Biological) or Toxin Weapons. A lessons-learned exercise for the United Nations Mission in the Syrian Arab Republic, p. 10, https://disarmament.unoda.org/publications/more/syrian-ll-report/ (accessed 2024)
[13] Ibid. p. 11.
[14] Robert Koch Institute (2023): Evaluation of the Capstone Exercise 2020|2022. Executive Report, p. 22. https://www.rki.de/EN/Content/infections/biological/projects/UNSGM/capstone_excercise.pdf?__blob=publicationFile (accessed 2024)
[15] Training Activities in Support of the Secretary-General's Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons (UNSGM), https://disarmament.unoda.org/wmd/sgm-training-activities/ (accessed 2024)

mechanism and ensuring its readiness therefore calls for concerted action by UN member states such as in the form of nominating experts and laboratories with relevant expertise to the roster, hosting training courses, or providing other resources to the UNSGM.

Open Source Information and the BWC

Gunnar Jeremias ZNF, University of Hamburg

The Abbreviation OSINT is composed of the terms Open Source, information, and intelligence. **Open Source** is here understood as all sources that are not classified and include hence also information material that has to be bought from suppliers (such as specific satellite images). While we exclude theft of information from the definition, legality of access is not necessarily a qualifier, as already the use of certain websites might be legal in one country, but not in another. **Information** can be defined as "the subset of knowledge that is required by a specific person or group in a specific situation and is often not explicitly available "[16]. This implicitly includes that it is verifiable by scientific standards. **Intelligence** can be understood as actors that "collect, analyze and report information that reveals the intentions of foreign governments", encompassing mostly security and economy[17]. While intelligence is widely seen as governmental activity including espionage and other covert investigation methods, Open Source Information is known to be used by civil society actors in the investigation and publication of possibly illicit armament activities or of the use of prohibited arms[18]. International treaty organizations, on the other hand, are dependent on the mandate given to them by the member states.

For the BWC and a possible future verification mechanism implemented by a future international authority, one question is, whether it will be allowed as the IAEA but not the OPCW to use OSI. Both civil society (including academia) and an organization could, however, use OSI to monitor compliance (avoiding the term verification, which is understood as a process building on technical facts but interpreted by political actors in political contexts) with the treaty provisions. Another question is what can be expected by the use of OSI. It is worth looking separately at attempts to investigate alleged use and (with the absence of known bioweapons stockpiles) the upstream field of existing, emerging, and developing capacities and capabilities through dual-use research and production capabilities in a given country.

It can be expected that different from the recent past where only highly qualified state-owned units would have such abilities, civil society actors can become active in investigating outbreaks, namely forensics, and attribution, especially when a pathogen spreads in a population – remember the manifold public websites on which deep scientific information (and its interpretation) were available for the actual SARS-CoV2 variants and context information. The existence of websites with public relevant information such as about unusual disease outbreaks etc. further increases the chances for civil society activities in this regard. When it comes to (contamination with) toxins, both for sample taking and analysis, civil society can be expected to try to have its share in the investigation, but due to the greater complexity in sample taking (from expectedly closed sites) and analysis, OSI investigations will likely face its boundaries much earlier.

For the *ex-ante* part of OSI-based compliance monitoring the challenges are similar for all possible actors, and start much before it comes to information gathering about suspicious sites. There is, for example, no consensus among experts, on how non-compliance is defined and how it could be detected and described. OSI would hence often be used to build transparency about context information. The information density of many information sources with high relevance in other fields is rather low in the biotech area. Satellite images for instance give little valuable information without the possibility of on-site visits, which are clearly out of the scope of civil OSI use.

An international organization could and should be mandated to use the full spectrum of information, as even the bureaucracies of well-developed states cannot be expected to gather all relevant information in declarations, and it would also weaken an international authority if it would not be allowed to get on the same level of knowledge. This is also the only practicable way to enable a verification organization to deal with both disinformation and misinformation.

[16] Fachrichtung Informationswissenschaft: Definition Information https://saar.infowiss.net/projekte/ident/themen/definition-information/ (accessed 2024).
[17] National Security Agency (NSA) https://www.intelligencecareers.gov/nsa (accessed 2024).
[18] Deiseroth, D. Societal Verification – wave of the future?, UNIDIR disarmament forum, three 2010, Arms Control Verification (2010).

On-site Inspections – an Important Verification Tool

Ralf Trapp, Independent Disarmament Consultant

Verification can be described as purposeful fact-finding within a usually cooperative, supervisory procedure aimed at building trust in treaty compliance. It gathers, preserves/protects, and analyses evidence (such as testimony, documented observations, samples and specimen, and the results of their assessment/analysis) to test compliance hypotheses. Its results support political and legal decision-making about State compliance.

Inspections are one of the tools that are used to gather such information. They can be mandated to verify declared data, to confirm that activities and features are consistent with expectations of a treaty-compliant situation, to collect evidence to support or refute concerns of possible non-compliance, or to gather information that may lead to the identification of those responsible for an act of confirmed non-compliance. Inspections also gather contextual information needed to reconstruct an incident and its circumstances in space and time.

A key aspect of collecting evidence is the assessment of authenticity to detect and exclude fabricated, staged, or altered evidence. Also, inspectors must ensure the integrity and validity of all procedures and methods they apply, from evidence collection, storage and transfer, to analysis and reporting, including an unbroken chain of custody. They must also select evidence that is both relevant and sufficiently significant to their mandate. Techniques used to interrogate evidence must be scientifically sound and appropriately validated, and the entire analytical system must be quality-assured. Reports must be tailored to the different needs and expectations of the audiences (technical experts advising governments, lawyers, and policy experts/diplomates). The scope of reporting of inspection results must align with the mandate given to an inspection, and provide sufficient insight into the validity of the technical conclusions drawn as well as their limitations.

An example for an effective, albeit complex, verification system is that of the Chemical Weapons Convention (CWC). It provides for different types of routine inspections based on the risk posed by certain military and industrial facilities to the object and purpose of the CWC, as well as special types of inspections to investigate cases of suspected non-compliance (challenge inspection) including investigations of allegations of the use of chemical weapons. In addition, the OPCW has conducted missions not anticipated in the treaty itself, such as technical assistance visits to support States Parties with implementation issues or national investigations of CW-related incidents, and *ad hoc* mechanisms devised to resolve questions about apparent gaps and inconsistencies in Syria's chemical weapons declaration (Declaration Assessment Team - DAT) and to investigate reports of chemical weapons uses (Fact-finding Mission - FFM). Most recently, the Director-General established an Investigation and Identification Team (IIT) in response to a decision of the Conference of the States Parties to address the threat of chemical weapons uses. This IIT has been mandated to gather information to identify those individuals and entities responsible for CW uses in Syria. The OPCW also supported UN missions established by the Security Council (the UN-OPCW Joint Mission to eliminate the Syrian chemical weapons, and the Joint Investigative Mechanism (JIM) of the UN and the OPCW to identify those responsible for confirmed cases of use of chemical weapons in Syria), as well as the 2013 investigation of CW use reports in Syria, conducted under the UN Secretary General's Mechanism (UNSGM).

To implement on-site inspections effectively, the OPCW has set up a sophisticated array of human and technical capabilities. These include well-trained and experienced inspectors, fit-for-purpose inspection equipment for field use, an effective operations, planning, logistics, and communications structure that can call upon support also from the UN (in particular in the safety and security domain), a reach-back capability to external scientific and technical advice, and a network of Designated Laboratories for off-site sample analysis with labs that are thoroughly quality assured and have successfully participated in OPCW Proficiency Tests. This system does not come cheap, but its high operational, scientific and quality standards are essential for the confidence that States Parties have in its technical conclusions. Maintaining these high standards and an adequate operational capability remain a challenge for the OPCW.

So why spend time and money to maintain such a system? Firstly, it is a verification tool that operates to multilaterally agreed rules and standards - it reflects the level of intrusion and evidential standard that States Parties collectively have accepted as adequate for verification purposes whilst not unduly interfering with

their legitimate activities and interests. Secondly, it is a tool that takes verification to the actual sites of an incident or facility of concern, allowing inspectors to assess a situation *in situ,* collect evidence *there* for subsequent analysis, and to gather testimony of observers, victims and other relevant sources under conditions *they* can control.

For such a system to function as it should, four factors are essential: trust in the Organisation and the integrity and competence of its officers; trust in the methods, procedures and standards they apply; familiarity of the countries inspected with the procedures and tools inspectors are going to use; and - most importantly- constant support of the Organisation's leadership and its policy making organs.

Addressing Developments in S&T: A Need to Look Beyond the International

Barry de Vries, University of Gießen

To ensure the effectiveness of the prohibitions against chemical and biological weapons and to limit their proliferation it is necessary to go beyond the international level. Part of this is the incorporation of the prohibitions and regulations within the national legal framework. This will also be an essential part of the regulation of new technologies. It is therefore necessary to consider developments in science and technology not only at the international level but at the national as well. Like the international frameworks against chemical and biological weapons, national legislation also does not address all technological developments comprehensively. While the major prohibitions are generally phrased in a technologically neutral way, major regulatory aspects are linked to control lists of specific agents or technologies. In addressing newer technologies, a clear divide between the Global North and South can be identified, with a clear link being seen between the size and advanced nature of the chemical and pharmaceutical industries and the regulations. This is also linked to the overall level of regulations that exist about dangerous chemical and biological agents.

There are certain benefits to addressing technological developments at the national level. The first is that national measures can be more easily amended than international agreements. As a consequence, such changes generally require less time and allow for more flexibility, making them far better positioned to adequately and promptly respond to scientific developments. This can be seen in the fact that while many technological developments are still being debated in the context of the BWC and CWC, several states have already responded to them in their national regulations. The second benefit of addressing technological developments at the national level is that it will be possible to directly affect natural and legal persons. International agreements generally only bind states and therefore are incapable of regulating the behavior of individuals.

However, if this issue would only be addressed in the national context there would not be a uniform standard and divergent approaches would be followed in different states. This can already be seen in the currently diverging standards on the regulation of relevant technologies between the Global North and South. Therefore, it is necessary to have a hybrid approach where states potentially first seek to address these issues within their national framework while making efforts at adopting international minimum standards. It is likely that the initial impetus of such regulation will come from states with developed chemical and pharmaceutical industries. There is a significant divergence in the capacity to respond to technological developments through legislation or regulation of the Global North compared to the Global South. This is in part due to the higher concentration of the relevant industries in the Global North, meaning that the majority of the relevant industries will be covered. However, due to the growing industries in the Global South, the quicker dissemination of technology, and the democratization of production, threats can emerge if there is a lack of adequate governance. The issue here is whether there is the incentive and knowledge for the national legislator to respond appropriately to new developments in technology. It is likely here that the divergence that exists in states that have advanced chemical and biopharmaceutical industries compared to those that do not would increase and potential gaps would broaden creating possible areas of concern.

Workshop Programm (updated)

CBWNet expert workshop on
S&T developments with relevance for CWC and BWC
Hamburg, 17-18 Juni 2024

17 June 2024

13:30-13:45 Introduction

14:00-15:30 *Panel 1: S&T advice in the context of arms control and disarmament treaties. Chair: Gunnar Jeremias, ZNF/ University of Hamburg*

- The role of S&T advice in arms control and disarmament treaties (John R. Walker, Royal United Services Institute, Department of Science and Technology Studies, University College London)
- Science &Technology Advice for the Biological Weapons Convention (Una Jakob, Peace Research Institute Frankfurt)

Coffee break

16:00-17:30 *Panel 2: Developments in Life Sciences. Chair: Elisabeth Hoffberger-Pippan, Peace Research Institute Frankfurt*

- Developments in synthetic biology that are relevant to the BWC (Dan Sabatelli, German Association for Synthetic Biology)
- Developments in chemistry & biology- Lessons from the SPIEZ Convergence (Sophie Reiners, Spiez Laboratory)
- S&T around proteins. Challenges and opportunities for BWC and CWC (Anna Krin, ZNF/University of Hamburg)

18:00 *Informal Dinner*

18 June 2024

9:00-10:30 *Panel 3: Verification. Chair: Anna Krin ZNF/University of Hamburg*

- Resources and challenges for investigation under the United Nations Secretary-General's Mechanism (Ines Mergler, Robert Koch-Institute)
- Open-source information (Gunnar Jeremias, ZNF/University of Hamburg)
- On-site inspection - an important verification tool (Ralf Trapp, Independent Disarmament Consultant)

Coffee break

11:00-12:30 *Panel 4: Governance. Chair: Alexander Kelle, IFSH Berlin Office & CBWNet Network Coordinator*

- Addressing developments in S&T: A need to look beyond the international (Barry de Vries, University of Gießen)
- (Self) regulation in the industry (Marc-Michael Blum, Blum Scientific)

12:30-13:45 *Lunch*

14:00-15:30 Plenary discussion: S&T issues with a specific view on BWC verification. Chair: Gunnar Jeremias, ZNF/ University of Hamburg

15:30-15:45 Concluding remarks

Workshop ends

The CBW network for the comprehensive strengthening of norms against chemical and biological weapons (CBWNet)

The research project CBWNet is carried out jointly by the Berlin office of the Institute for Peace Research and Security Policy at the University of Hamburg (IFSH), the Chair for Public Law and International Law at the University of Gießen, the Peace Research Institute Frankfurt (PRIF) and the Carl Friedrich Weizsäcker-Centre for Science and Peace Research (ZNF) at the University of Hamburg. The joint project aims to identify options to comprehensively strengthen the norms against chemical and biological weapons (CBW).
These norms have increasingly been challenged in recent years, *inter alia* by the repeated use of chemical weapons in Syria. The project scrutinizes the forms and consequences of norm contestations within the CBW prohibition regimes from an interdisciplinary perspective. This includes a comprehensive analysis of the normative order of the regimes as well as an investigation of the possible consequences which technological developments, international security dynamics or terrorist threats might yield for the CBW prohibition regimes. Wherever research results point to challenges for or a weakening of CBW norms, the project partners will develop options and proposals to uphold or strengthen these norms and to enhance their resilience.
The joint research project is being funded by the Federal Ministry of Education and Research for four years (April 2022 until March 2026).

About this working paper:
The working paper is a collection of contributions from the participants of the CBWNet Expert Workshop on S&T developments with relevance for CWC and BWC held in Hamburg, on 17 and 18 June 2024.

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