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BACK TO THE FUTURE FOR VERIFICATION IN THE BIOLOGICAL DISARMAMENT REGIME?

JAMES REVILL, JOHN BORRIE
AND RICHARD LENNANE

UNIDIR UNITED NATIONS INSTITUTE FOR DISARMAMENT RESEARCH

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ABOUT THE AUTHORS

JAMES REVILL is Lead of the Weapons of Mass Destruction and Other Strategic Weapons Programme at UNIDIR and has primary responsibility for UNIDIR's compliance and enforcement work. His PhD from the University of Bradford in the United Kingdom focused on the evolution of the Biological and Toxin Weapons Convention (BWC).

JOHN BORRIE is Principal Adviser for Disarmament for the New Zealand Ministry of Foreign Affairs and Trade and a Non-resident Senior Resident Fellow at UNIDIR. His working experience has covered many aspects of arms control, disarmament, and humanitarian affairs. Prior to joining UNIDIR, Borrie worked on biological weapons issues at the International Committee of the Red Cross. Before that, he was a New Zealand disarmament diplomat during the BWC Ad Hoc Group negotiations and their aftermath. John has a PhD from the University of Bradford. The views expressed in this study are his and not those of the New Zealand Government.

RICHARD LENNANE is a Consultant with UNIDIR. He has long experience in multilateral disarmament and arms control, as an Australian diplomat involved in the Ad Hoc Group negotiations, a United Nations official and an NGO activist. Richard worked in the United Nations Office for Disarmament Affairs from 2001 to 2013, including as Head of the BWC Implementation Support Unit from its creation in 2007.

ABBREVIATIONS AND ACRONYMS

BWC	Biological and Toxin Weapons Convention
CWC	Chemical Weapons Convention
OPCW	Organisation for the Prohibition of Chemical Weapons
UAV	Uncrewed aerial vehicle
UNSCOM	United Nations Special Commission (for Iraq)
VEREX	Ad Hoc Group of Governmental Experts to Identify and Examine Potential Verification Measures from a Scientific and Technical Standpoint
WHO	World Health Organization
WMD	Weapons of mass destruction

SUMMARY

- 2022 marks twenty-one years since the termination of the Ad Hoc Group negotiations on a protocol to the Biological and Toxin Weapons Convention (BWC). The Ad Hoc Group process failed to agree on a robust regime capable of ensuring confidence in compliance with the BWC's prohibitions. In the time since, it has become virtually an article of faith among some States parties to the Convention that an analogous BWC protocol is desirable. Yet, this is not self-evident. While there are some elements of continuity today with the situation then, there have been many significant geopolitical, technological and economic changes.
- These developments generate both new challenges and new opportunities to strengthen the BWC. The convergence of biology with other disciplines over the last two decades has accelerated the pace of advances in the life sciences, some of which present considerable risks to the BWC and the wider biosecurity regime. For example, new genome editing techniques could contribute to novel biological weapons or rectify key limitations in past biological weapons. Other advances present opportunities to enhance aspects of the Convention's implementation, through for example better tools to monitor compliance than in the past.
- Since 2001, the wider political context has become less conducive to multilateral disarmament and arms control efforts as great power strategic rivalries have re-emerged. The picture is not altogether bleak. Emerging concerns over terrorism brought BWC States parties closer together on some issues and led to agreement around tools that complement BWC implementation. Concerns over bioterrorism also fostered greater roles for non-State actors from industry and academia in the governance of biological risks. However, this is in the face of an expanding spectrum of entities potentially able to exploit biology for hostile purposes ranging from mass, indiscriminate attacks to covert localized attacks and sabotage.
- To make sense of these challenges and opportunities, this report considers elements of change and continuity evident in the BWC regime over the last two decades. The analysis presented here is intended to prompt broader reflection about what BWC States parties can realistically do to address compliance challenges in the near future.
- Specifically, we identify three possible strategies for States parties to build confidence in compliance with the BWC. The first is for BWC States parties to establish a process analogous to the group of BWC verification experts (VEREX) established in 1991 to look once again at available verification technologies. Such a process needs to be open to all States parties and draw upon expertise from a variety of sources, including international organizations, the scientific community, academia, industry, and civil society. The assessment of compliance monitoring and verification technologies undertaken in such a "VEREX 2.0" could revisit those discussed in the past, as well as explore the potential of emerging tools and approaches, including microbial forensics and open-source data.

- However, even the most modern and effective verification technologies and investigative techniques will be of little use if there is no clear and accepted path for invoking and applying them in each situation. The formal channels for raising and responding to compliance concerns therefore need BWC States parties' careful attention. To this end, a second possible way forward entails the development of procedures for consultation and cooperation pursuant to Article V of the BWC. States parties could also consider developing more structured procedures relating to Article VI. These would set out exactly how allegations of non-compliance should be referred to the United Nations Security Council and consider procedures with which to investigate, for example, facilities alleged to be developing or stockpiling biological weapons. There is also a broader question of whether and how actors other than States parties might be involved in raising and responding to compliance concerns through different channels, including, but not limited to, the BWC.
- The two strategies above cannot be pursued effectively in isolation. Each needs augmented institutional capacity beyond the BWC's existing three-person Implementation Support Unit (ISU), as well as the development of a compliance ecosystem for the BWC and its related communities. This third approach requires:
    - Ensuring support for implementation of BWC Article X. Potentially this could be strengthened through some form of cooperation entity within the BWC regime to undertake a review of the systematic obstacles to international cooperation.
    - Establishing some form of science and technology review mechanism to monitor risk and opportunities from developments in the life sciences and related disciplines.
    - Strengthening engagement and interaction with other stakeholders, including industry, academia, and civil society.
    - Building greater transparency in dual-use biological research by developing confidence-building measures.

These three strategies could form part of a balanced package of measures for consideration by BWC States Parties at the Ninth Review Conference rescheduled for November 2022. The contours of such a package are rather distinct from the 1990s vision of a comprehensive legally binding instrument containing a relatively intrusive verification regime. While less ambitious, our conclusion is that such an approach better fits current political and technological realities and could set in motion a path to significantly strengthening the BWC at this critical juncture.

1 INTRODUCTION

In 1991, Iraq was defeated in the first Gulf War, a conflict in which its biological weapons programme became a headline of international concern. It also served to underline the lack of verification measures in the 1972 Biological and Toxin Weapons Convention (BWC), a disarmament agreement originally forged during a brief period of Cold War detente between the United States and the Soviet Union.

The Cold War's end, and the outcome of the subsequent Gulf War, served to accelerate negotiations on a legally binding Chemical Weapons Convention (CWC), complete with a detailed verification mechanism to ensure confidence in compliance with that Convention's prohibitions. In this context, some governments and experts also saw an opportunity for the biological weapons regime to be strengthened. At the third five-yearly BWC Review Conference, in 1991, the BWC States parties agreed to establish an Ad Hoc Group of Governmental Experts "to identify and examine potential verification measures from a scientific and technical standpoint".[1]

This group of BWC verification experts, usually referred to simply as "VEREX", reported back in September 1993 with its evaluation of 21 potential verification measures. The VEREX report concluded that combinations of these verification measures "would contribute to strengthening the effectiveness and improve the implementation of the Convention".[2] However, the report also acknowledged various uncertainties and potential difficulties, including:

> *"Certain current scientific and technical shortcomings of some measures… These included the acknowledgement that some technologies associated with particular measures are limited by the commercial availability of equipment, materials and stages of development."*[3]

Following VEREX's work, in 1994 the BWC's depositories – the Russian Federation, the United Kingdom and the United States – convened a Special Conference of States Parties. Drawing on the findings of the VEREX report, this conference agreed to establish a further Ad Hoc Group to commence work on a legally binding draft protocol. Although often referred to as a verification protocol, the protocol negotiations were actually oriented toward devising a balanced package comprising four key components: definitions; enhanced confidence-building measures; measures to promote compliance, including the verification measures VEREX discussed; and measures to ensure effective and full implementation of Article X of the BWC, which deals with international cooperation.[4]

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1 F. Lentzos, Compliance and Enforcement in the Biological Weapons Regime, WMD Compliance and Enforcement Series no. 4, UNIDIR, 2019, https://doi.org/10.37559/WMD/19/WMDCE4, p. 17.

2 BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Summary Report, BWC/CONF.III/VEREX/8, 24 September 1993, https://undocs.org/BWC/CONF.III/VEREX/8, para. 32.

3 Ibid., para. 22.

3 BWC, Special Conference, Final Report, BWC/SPCONF/1, 30 September 1994, https://undocs.org/BWC/SPCONF/1, part II, para. 36.

Between 1995 and 2001, the Ad Hoc Group met for 24 sessions. By 1997 the group had progressed to negotiating on a rolling draft text with work focused on resolving differences between alternatives presented within square brackets. However, by the end of 2000, "strong conceptual differences in views"[5] remained over several key issues.[6] These included investigations, compliance measures and cooperation.[7] Such differences were reflected in the last version of the rolling text, which was far from a consensus text and included more than 1,000 pairs of square brackets around contested language.[8]

In 2001, Ambassador Tibor Tóth of Hungary, chair of the Ad Hoc Group, proposed a compromise text to resolve evident differences in perspective among delegations – the so-called "Composite text" or CRP.8.[9] The goal of this proposed compromise was to secure agreement on a protocol by the next five-yearly BWC Review Conference in 2001.

The BWC protocol was not to be. Several States criticized the composite text and/or sought the resumption of "substantive negotiations based on the rolling text".[10] However, in mid-2001, the United States rejected the draft protocol compromise because, it said, the arrangement would be ineffective.[11] It was also clear the United States government had concerns about protecting national security information related to biodefence, while the powerful US pharmaceutical and biotechnology industries feared the protocol would lead to the theft of proprietary commercial information.[12] The rejection of the composite text by the United States catalysed the collapse of the Ad Hoc Group negotiations.

The concerns of the United States were hardly a surprise to other Ad Hoc Group delegations, and to some extent those of other major powers shared them. In the sessions leading up to 2001, most Western governments had even abandoned the term "verification" in favour of

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5 See BWC, Ad Hoc Group, Procedural Report, BWC/AD HOC GROUP/54, 18 December 2000, https://documents.unoda.org/wp-content/uploads/2021/07/BWC_AHG_54-converted.pdf, para. 8.

6 T. Tóth, "Time to Wrap Up", CBW Conventions Bulletin, no. 46, December 1999, pp. 1–3, http://www.sussex.ac.uk/Units/spru/hsp/documents/cbwcb46.pdf. See also R. Lennane, "Blood, Toil, Tears and Sweat: The Biological and Toxin Weapons Convention since 2001", Disarmament Forum, Toward a Stronger BTWC, no. 3, September 2006, https://unidir.org/files/publications/pdfs/toward-a-stronger-btwc-en-336.pdf.

7 See BWC, Ad Hoc Group, Procedural Report, BWC/AD HOC GROUP/54, 18 December 2000, https://documents.unoda.org/wp-content/uploads/2021/07/BWC_AHG_54-converted.pdf, para. 8.

8 The available version of the rolling text, BWC/AD HOC GROUP/56-1 Annex A, has 1222 left square brackets and 1221 right square brackets. BWC, Ad Hoc Group, Procedural Report, BWC/AD HOC GROUP/56-1, 18 May 2001, https://docs-library.unoda.org/Biological_Weapons_Convention_-_Ad_Hoc_Group_Twenty-Third_session_(2001)/BWC_AHG_56_Part.I.pdf.

9 BWC, Ad Hoc Group, Protocol to the Convention on the Prohibition of the Development, production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, BWC/AHG/CRP.8, 30 May 2001, https://undocs.org/BWC/ADHOCGROUP/CRP.8.

10 For example, a joint statement released on 4 May 2001, stated: "We firmly believe that the Ad Hoc Group should immediately resume substantive negotiations based on the rolling text to achieve consensus on outstanding issues". China, Cuba, Islamic Republic of Iran, Indonesia, Libyan Arab Jamahiriya, Pakistan and Sri Lanka, Joint statement on the process of the BTWC Ad Hoc Group Negotiations, Ad Hoc Group, BWC/AD HOC GROUP/WP.451, 4 May 2001, https://docs-library.unoda.org/Biological_Weapons_Convention_-_Ad_Hoc_Group_Twenty-Third_session_(2001)/BWC_AHG_wp.451.pdf.

11 D. Mahley, "Statement of the United States to the Ad Hoc Group of Biological Weapons Convention States Parties", 25 July 2001.

12 As Nikita Smidovich notes, "[US acceptance of the CWC] was partly made possible by the fact that the relevant industry accepted the treaty, which was because they felt some 'historical guilt' about industry involvement with chemical weapons. This factor was not the case for the Biological Weapons Convention; industry did not support the development of verification for the convention and has never accepted proposals for intrusive inspections, especially for routine on-going monitoring." H. Wilson and N. Smidovich, "Perspectives on UNSCOM and UNMOVIC: An Interview with Nikita Smidovich", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 184–87, https://doi.org/10.1080/00963402.2021.1941564.

softer terms such as "ensuring" or "enhancing confidence in BWC compliance" in their Ad Hoc Group interactions and public statements. Nevertheless, many countries participating in the Ad Hoc Group were critical of the United States for its rejection of the draft protocol. Reactions ranged from "disappointment" among Western countries to much harsher criticism from some States of the Non-Aligned Movement (NAM).[13]

Twenty-one years after the termination of the BWC Ad Hoc Group negotiations, the notions that a verification protocol is desirable and that negotiations in it should be resumed are almost articles of faith among some States parties.[14] Yet it is clear that, in 2001, the Ad Hoc Group (a negotiation two of the authors of this paper participated in) was some way from agreement on a robust regime capable of ensuring confidence in compliance with the BWC's prohibitions when it collapsed.[15] Moreover, even if there are some elements of continuity in the biosecurity sphere since then, much has also changed – geopolitically, technologically and economically. It is far from clear whether the ideas contained in the 2001 composite text would have significantly improved confidence in compliance with the BWC in the subsequent environment, let alone the one we find ourselves in today. Certainly, the contemporary challenges associated with hostile misuse of biological agents look quite different today to those of 1994, or even those of 2001.

It is time for look with fresh eyes at the question of how compliance with the BWC can be strengthened. Just as new challenges have emerged and other aspects of the biological disarmament regime have changed, so too have new opportunities to strengthen the Convention. The BWC remains a fundamental component of a wider set of measures and activities that together work to manage the risks of dual-use biology. A well-designed set of compliance measures that cumulatively takes advantage of wider changes and the lessons to be learned in the decades since the work of the Ad Hoc Group might strengthen confidence in the BWC. Form should follow function, and a protocol is but one means to this end: there are other alternatives to consider, especially if they offer a more feasible, balanced package.

To interrogate this matter, sections 2 and 3 of this report outlines some of the salient technological, institutional, and political developments of relevance to the biological weapons regime over the last 20 years. Section 4 outlines some aspects that, in contrast, do not appear to have changed fundamentally. Building on this analysis of continuity and change, section 5 identifies some steps that States parties and others interested in the BWC might consider in seeking to strengthen it at the upcoming Ninth Review Conference and beyond.

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[13] For an early example, see the working paper submitted by Cuba, BWC/AD HOC GROUP/WP.455, 20 August 2001, https://docs-library.unoda.org/Biological_Weapons_Convention_-_Ad_Hoc_Group_Twenty-Fourth_session_(2001)/BWC_AHG_Wp.455.pdf.

[14] As much is evident in statements by the Non-Aligned Movement, which have consistently advocated the resumption of multilateral negotiations on a legally binding protocol. See for example Azerbaijan, "General Statement on Behalf of the Non-Aligned Movement and other States Parties to the Biological and Toxin Weapon Convention, December 2019, http://geneva.mfa.gov.az/files/1.%20General%20Statement%20for%20MSP19%20-%20Delivered%20by%20Yusif%20HUSEYNOV.pdf.

[15] BWC, Ad Hoc Group, Protocol to the Convention on the Prohibition of the Development, production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, BWC/AHG/CRP.8, 30 May 2001, https://undocs.org/BWC/ADHOCGROUP/CRP.8.

1.1 DEFINITIONS

Compliance and verification are important terms subject to different interpretations that are frequently underpinned by competing assumptions.[16]

Compliance	In this report, compliance is understood as adherence to the obligations of the BWC. This includes positive obligations upon States parties to undertake certain actions (i.e. national implementation or promotion of international cooperation) and negative obligations (e.g. not to produce or stockpile biological weapons).
Verification	Verification is understood as a "structured and systematic means of a. providing an increased level of assurance that States Parties are complying with the prohibitions and obligations of the Convention; and b. promptly, effectively and impartially investigating cases of alleged or apparent non-compliance with the prohibitions of the Convention."[17]

In considering various verification methods and technologies, a distinction is made between verifying alleged use of a biological weapon and verifying violations of other prohibitions of BWC such as development, production, stockpiling or other acquisition of biological weapons. Although not necessarily mutually exclusive, verifying alleged use is a different activity from verifying other treaty violations.

Verification of alleged use would typically involve a field investigation, potentially in a conflict or post-conflict setting. The United Nations Secretary-General's Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons (UNSGM) was established for this purpose and is separate from the BWC. Such an investigation may have much in common with – or overlap with – investigation into natural or non-deliberate outbreaks of disease. In some scenarios, it logically follows that suspicion about biological weapons use will emerge following an epidemiological investigation of a disease outbreak.

Verifying other violations would be rather different and involve inspection or monitoring of biological facilities (laboratories, industrial production facilities, storage, and transport infrastructure, etc.). There is much that can be learned from verification regimes in other treaties, such as the Chemical Weapons Convention or the work of the IAEA, in designing any BWC verification initiative. However, it is important to stress that any effort to verify the BWC will require an approach specific to biological weapons. As Lentzos notes, "biology defies material accountancy-type verification methodologies" applied in the work of the IAEA or OPCW.[18]

[16] R. Lennane, "Verification for the BTWC: If Not the Protocol, Then What?", Disarmament Forum, no. 1, 2011, pp. 39–50, https://css.ethz.ch/en/services/digital-library/publications/publication.html/128684.
[17] Ibid., p. 41.
[18] F. Lentzos. "Compliance and Enforcement in the Biological Weapons Regime." WMDCE Series No. 4. 2019 Geneva, Switzerland: UNIDIR. https://doi.org/10.37559/WMD/19/WMDCE4.

2 CHANGES IN SCIENCE AND TECHNOLOGY

Since 2001, there have been major changes in science and technology of relevance to the Biological Weapons Convention. The convergence of biology with other disciplines, including information technology, over the last two decades has accelerated the pace of advances in the life sciences. In turn, this has unlocked new and exciting roles for biotechnology across a range of different areas and fuelled expectations of a growing global "bioeconomy" valued at trillions of dollars each year.[19]

2.1 RISKS...

Some of these changes in science and technology present risks to the BWC and the wider regime against biological weapons. Some of the risks stem from the potential for new technologies to enable new biological weapons that convey particular, novel advantages to the user (e.g. enhanced virulence or increased transmissibility) or rectify limitations in past generations of biological weapons (e.g. by increasing the resilience of traditional biological agents to environmental degradation).

Other advances could radically change the very nature of biological warfare. For instance, affective computing – combining machine learning systems with biosensors – is already unlocking a new understanding of human emotional triggers. In turn, this could enable the manipulation of life processes, "including the processes of cognition, development, reproduction, and inheritance".[20] To provide another example, microorganisms capable of rapidly degrading particular materials, such as plastics, raises the prospect of the development or use of anti-materiel biological weapons in the future.[21]

Yet other advances could aid the delivery and targeting of biological weapons. With regards to delivery, some BWC States parties have raised concerns about the growing availability of uncrewed aerial vehicles (UAVs) that might be used in such a role.[22] Concerning targeting, growing repositories of data on human genomes could be exploited to "map infection susceptibilities in specific populations", which, in turn, could enable the development of "ethnically targeted weapons".[23] However, to date this topic has received limited attention in terms of its implications for BWC compliance.

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[19] National Academies of Sciences, Engineering and Medicine, Safeguarding the Bioeconomy, 2020, https://doi.org/10.17226/25525. See also J. Cumbers, "New McKinsey Report Sees a $4 Trillion Gold Rush in this One Hot Sector. Who's Selling Picks and Shovels?", Forbes, 30 May 2020, https://www.forbes.com/sites/johncumbers/2020/05/30/mckinsey-report-4-trillion-gold-rush-bioeconomy-synthetic-biology.

[20] M. Meselson, "Averting the Hostile Exploitation of Biotechnology", CBW Conventions Bulletin, June 2020, pp. 16–19, http://www.sussex.ac.uk/Units/spru/hsp/documents/Pages from cbwcb48.pdf.

[21] It is unclear whether anti-materiel weapons would be covered under Article I of the BWC. United States, "Article I: Reinforcing the Core Prohibition of the Biological Weapons Convention", BWC/CONF.VIII/WP.14, 2016, https://meetings.unoda.org/section/bwc-revcon-2016-documents.

[22] As the United Kingdom remarked in 2015, "Research on aerobiology directed at optimising agricultural spraying techniques has included field trials on the use of unmanned aerial vehicles (UAVs)". United Kingdom, "Advances in Science and Technology: Production, Dispersal and Delivery Technologies", BWC/MSP/2015/MX/WP.12, 6 August 2015, https://undocs.org/BWC/MSP/2015/MX/WP.12.

[23] L. Warmbrod. J. Revill and N. Connell, Advances in Science and Technology in the Life Sciences and their Implications for Biosecurity and Arms Control, UNIDIR, 2020, https://doi.org/10.37559/SecTec/20/01, p. 11. see also ICRC, "Biotechnology, Weapons and Humanity", BMA Professional Division Publications, 2004.

Further risks lie in the changing nature of life science research. Recent advances in genome editing tools, such as CRISPR-Cas9, enable scientists to edit DNA more easily, accurately, and swiftly than before.[24] Tools like CRISPR mean that DNA manipulation no longer depends on being able to physically acquire tangible samples of DNA. Rather, strands of tailored DNA can be produced from scratch based on digital data; alternatively, digital data can be sent to synthesis companies for conversion into tangible strains. This presents a considerable challenge for export control regimes seeking to regulate the transfer of sensitive materials and equipment for non-proliferation purposes.

Three other factors add further complication to efforts to ensure the BWC's prohibitions are upheld. First, the "de-skilling" of biology through technologies like CRISPR will provide access to powerful tools to manipulate pathogens for hostile purposes to a wider range of actors.[25] Second, so-called "cloud labs" are now appearing; that is, automated, remote research facilities that undertake biological experimentation. These theoretically reduce the costs of experiments and provide more people with access to biological experimentation.[26] Third, technologies are emerging that fundamentally change the footprint of any biological weapons production facility. For example, Millet and colleagues note that "single-use bioreactors have led to the emergence of flexible manufacturing facilities that produce many products at a site, or sites which can be rapidly reconfigured to produce different products".[27]

Indeed, these changes reflect and further contribute to an evolving research landscape in which ever more actors and institutions are working on potential dual-use research, resulting in ever more applications (as illustrated in Figure 1). In parallel to the growth in publications, institutions and patents, new approaches to research have emerged. Examples include the upswing in undergraduate and high-school biology teams competing in the International Genetically Engineered Machine (iGEM) competition and the swelling of "do-it-yourself" bio groups operating outside traditionally structured laboratory environments. These trends have led some to speak of the "democratization" of biology, and they raise the prospects for cheaper, more accessible biological solutions to local challenges.[28] Moreover, such entities have demonstrated innovative approaches to safety and security. For example, the iGEM Competition has developed sophisticated biosecurity and biosafety training and assessment measures[29] and many "do-it-yourself" bio laboratories have developed internal oversight mechanisms.

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[24] Spiez, "Spiez CONVERGENCE: Report on the second workshop", 5–8 September 2016, Available at: https://www.spiezlab.admin.ch/en/home/meta/refconvergence.html.

[25] United States of America, "Tacit Knowledge: The Concept and Its Implications for Biological Weapons Proliferation", BWC/MSP/2015/MX/WP.6, 30 July 2015, https://undocs.org/BWC/MSP/2015/MX/WP.6. See also J. Revill and C. Jefferson, "Tacit Knowledge and the Biological Weapons Regime", Science and Public Policy, vol. 41, no. 5, October 2014, pp. 597–610, https://doi.org/10.1093/scipol/sct090.

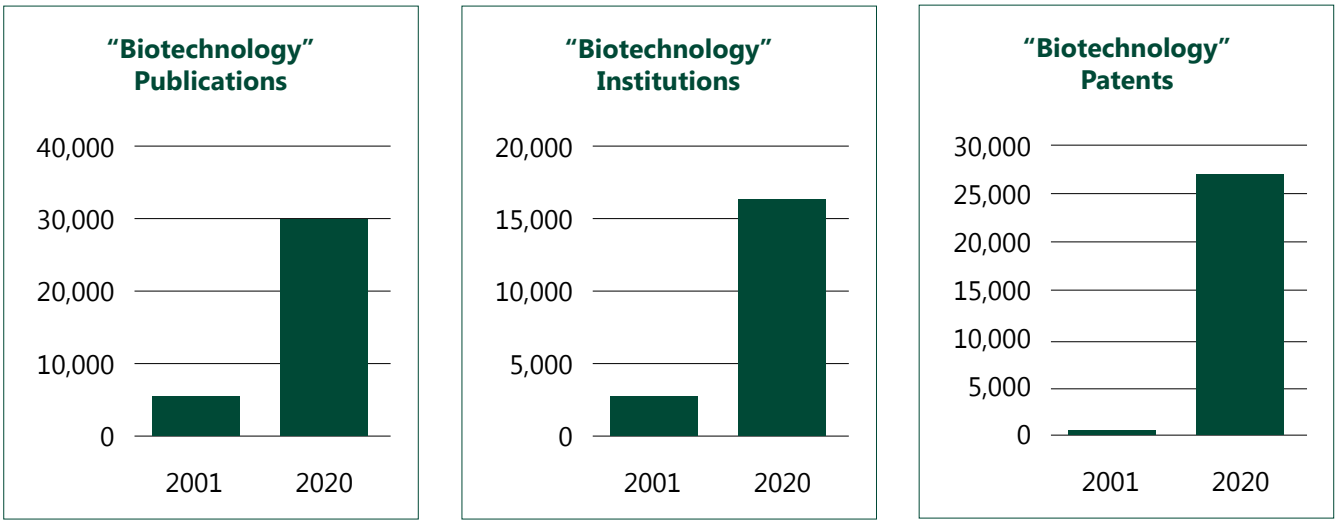
[26] F. Lentzos and C. Invernizzi, "Laboratories in the Cloud", Bulletin of the Atomic Scientists, 2 July 2019, https://thebulletin.org/2019/07/laboratories-in-the-cloud.

[27] P. Millett et al., "Feasibility of Onsite Verification", in J.P. Zanders (ed.), Verifying the BTWC in a Fast-Changing World (Forthcoming).

[28] As one expert is quoted, "Open science and DIY biology can fix the technological gap we are facing in Africa." S. Ravindran, "How DIY Technologies are Democratizing Science", Nature, 17 November 2020, pp. 509–511, https://doi.org/10.1038/d41586-020-03193-5.

[29] iGEM, 'Safety and Security at iGEM', https://old.igem.org/Safety.

FIGURE 1. *Changes in biotechnology publications, publishing institutes and patents, 2001–2020*



These are welcome developments, but as the life science community continues to grow the potential remains for a greater number of actors to exploit biology for hostile purposes. It does not follow that it is now easy to produce viable biological weapons capable of causing mass casualties or destruction: it remains difficult and probably still requires specialist knowledge as well as significant time and resources.[30] Yet there is no doubt that the proliferation of knowledge and tools relevant to biological research means the overall landscape is changing in ways likely to increasingly complicate efforts to monitor compliance with the BWC unless the regime can respond and adapt.[31]

2.2 ... AND OPPORTUNITIES

Changes in science and technology are not always detrimental to the BWC. Several developments present opportunities for enhancing aspects of this Convention. In terms of the provision of assistance under Article VII, the digitization of data can enable more efficient acquisition and sharing of pathogen data. For example, following the outbreak of COVID-19, researchers were able to sequence and share online the genetic makeup of the virus in days. This enabled researchers to begin the search for vaccines far sooner than in the past. In comparison, following the outbreak of SARS-CoV-1 in 2003, the same process took nearly three months.[32]

[30] T. Taylor, "Lessons to Be Drawn from the Search for Iraqi WMD", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 180–183, https://doi.org/10.1080/00963402.2021.1941553.

[31] As Sellström points out, "the detection of a 'garage'-type undercover biological-weapons program, or of small yet strategically significant weapons, is quite challenging". Å. Sellström, "Lessons from Weapons Inspections in Iraq and Syria", AJIL Unbound, vol. 115, 2021, pp. 95–99, https://doi.org/10.1017/aju.2021.5.

[32] See, for example, I. Le Guillou, "Covid-19: How Unprecedented Data Sharing has Led to Faster-Than-Ever Outbreak Research", Horizon Magazine, 23 March 2020, https://ec.europa.eu/research-and-innovation/en/horizon-magazine/covid-19-how-unprecedented-data-sharing-has-led-faster-ever-outbreak-research.

Of note for this paper are the possibilities raised by technologies to monitor BWC compliance. As noted above, VEREX in the early 1990s was the last time that States parties systematically assessed technologies for detecting and investigating non-compliance in a multilateral context. VEREX's central conclusions – that a combination of measures would help in "strengthening the effectiveness and improve the implementation of the Convention" – may hold true today.[33] Since the 1990s, the science and technology of relevance to assessing compliance has significantly enhanced the potential of the 21 verification measures VEREX considered. And potential new techniques such as "bioforensics" and machine learning are available, as well as social media tools.[34] As illustrated in Table 1, these could enable States parties, international organizations and perhaps other actors to identify anomalies and build a better picture of a State's compliance than in the past.[35]

TABLE 1. *Illustrative examples of advances in tools to monitor and verify compliance*

Surveillance of publications	The scanning of relevant scientific literature was recognized as potentially providing "useful information and help in the selection of sites and activities for inspections, at a low cost and with a low level of intrusiveness".[36] Since the early 1990s, the emergence of online tools and bibliometric databases (e.g. Scopus or Web of Science), as well as academic search tools (e.g. Google Scholar) have improved the surveillance of publications.
Surveillance of legislation	The collection and analysis of relevant legislative or regulatory information can provide useful indicators of a State's compliance with the BWC. This can also help identify sites and activities for inspection.[37] Since 1993, online tools and wider United Nations activities (e.g. the Security Council resolution 1540 database) have enhanced the surveillance of national legislation and regulatory measures.

[33] One of UNSCOM's valuable lessons is that a multi-tool approach is far more reliable and credible than depending on a limited number of options Gabriele Kraatz-Wadsack, "Monitoring and Verification in the Biological-Weapons Area", Nonproliferation Review, 2021, https://doi.org/10.1080/10736700.2020.1865629.

[34] As Smidovich notes: "New technologies have dramatically enhanced possibilities for verification. There now are many more powerful technological tools that could be used for verification purposes than were available to UNSCOM and UNMOVIC". H. Wilson and N. Smidovich, "Perspectives on UNSCOM and UNMOVIC: An Interview with Nikita Smidovich", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 184–87, https://doi.org/10.1080/00963402.2021.1941564.

[35] F. Lentzos, "Monitoring Iraq's Dual-Use Capabilities: An Interview with Gabriele Kraatz-Wadsack", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 172–76, https://doi.org/10.1080/00963402.2021.1941537.

[36] BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Summary of Work for the Period 23 November to 4 December 1992, BWC/CONF.III/VEREX/4, 8 December 1992, https://undocs.org/BWC/CONF.III/VEREX/4, p. 9; and BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Report, BWC/CONF.III/VEREX/6, 1993, https://undocs.org/BWC/CONF.III/VEREX/6, p. 5.

[37] BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Summary of work for the period 23 November to 4 December 1992, BWC/CONF.III/VEREX/4, 8 December 1992, https://undocs.org/BWC/CONF.III/VEREX/4, p. 11; and BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Summary of Work of for the Period 24 May to 4 June 1993, BWC/CONF.III/VEREX/6, 8 June 1993, https://undocs.org/BWC/CONF.III/VEREX/6, p. 7.

TABLE 1. *continued*

Data on transfers, transfer requests and production	VEREX recognized that the "collection and analysis of relevant data (like national exports and imports, government and industrial production statistics, culture collection records, etc.)" provided further background for facility investigations, as well as assisting in the selection of sites and activities for inspectors.[38] Moreover, for the United Nations Special Commission (UNSCOM) in Iraq, an "understanding of global trade was also critical on the biological side".[39] As Gunnar Jeremias noted, the development of online, publicly accessible databases presents additional opportunities for the reliable collection of other kinds of data that could be used in support of monitoring or assessing compliance with the BWC.[40] This could be advanced further through the use of an Automated Identification System for ship tracking and maritime intelligence and monitoring of financial transactions.[41]
Satellite surveillance	Satellite data has long been employed in biological weapons-related investigations. UNSCOM, for example, recognized the value of satellites to determine the dimensions of a facility and its possible functions.[42] BWC States parties also considered the role of satellite data during the VEREX process. During these discussions, Sweden for example suggested that satellite data could help identify facilities and activities as well as military exercises. However, the "ground special resolution" of commercially available satellite data in the early 1990s was limited to an estimated 5–10 metres.[43] At present, there are hundreds of commercial satellites from many different countries. As Melissa Hanham indicates in another paper in this series, "Multiple sensors controlled by multiple countries raises confidence in what is being recorded from space".[44] In addition, the ground special resolution of commercially available satellite data is considerably better than that available to VEREX, with 30-centimetre resolution satellite imagery now commercially available. Combined with other data (e.g. photos, videos, social media and trade flows), advances in satellite data could enhance any future investigation of biological weapons allegations.

[38] BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Summary of Work for the Period 23 November to 4 December 1992, BWC/CONF.III/VEREX/4, 8 December 1992, https://undocs.org/BWC/CONF.III/VEREX/4, p. 12; and BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Summary of Work of for the Period 24 May to 4 June 1993, BWC/CONF.III/VEREX/6, 8 June 1993, https://undocs.org/BWC/CONF.III/VEREX/6, p. 9.

[39] T. Taylor, "Lessons to Be Drawn from the Search for Iraqi WMD", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 180–183, https://doi.org/10.1080/00963402.2021.1941553.

[40] On how this has worked in the chemical weapons regime, see Jeremais's contribution to J. Revill and J. Borrie (eds.), Science and Technology for WMD Compliance Monitoring and Investigations, WMD Compliance and Enforcement Series no. 11, UNIDIR, 2020, https://doi.org/10.37559/WMD/20/WMDCE11.

[41] T. Taylor, "Lessons to Be Drawn from the Search for Iraqi WMD", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 180–183, https://doi.org/10.1080/00963402.2021.1941553.

[42] Ibid.; and H. Wilson and N. Smidovich, "Perspectives on UNSCOM and UNMOVIC: An Interview with Nikita Smidovich", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 184–87, https://doi.org/10.1080/00963402.2021.1941564.

[43] BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, "Surveillance by Satellite (Off-Site)", BWC/CONF.III/VEREX/WP.74, 1 December 1992, https://undocs.org/BWC/CONF.III/VEREX/WP.74.

[44] J. Revill and J. Borrie (eds.), "Science and Technology for WMD Compliance Monitoring and Investigations", WMD Compliance and Enforcement Series no. 11, UNIDIR, 2020, https://doi.org/10.37559/WMD/20/WMDCE11.

TABLE 1. *continued*

Aerial surveillance	Aerial surveillance covers "a variety of techniques operated by manned and unmanned aerial vehicles … that enable, to varying degrees, the detection, description, measurement or identification of some property of an object of interest without actually coming into physical contact with the object".[45] VEREX concluded that aerial sensing was potentially useful to "detect changes at the site", "monitor levels and changes in activities", "for detailed mapping", and to "perform ancillary (logistic) functions in relation to off-site observation and on-site inspection measures".[46] Since the early 1990s, advances made in un-crewed aerial vehicle technology have greatly improved their surveillance capabilities.[47] In this regard, aerial surveillance tools were successfully applied in the surveillance of chemical weapons facilities to the point that the Organisation for the Prohibition of Chemical Weapons (OPCW) Scientific Advisory Board's Temporary Working Group on Investigative Science and Technology recommended making use of UAVs to "provide real-time two- or three-dimensional images of an investigation site prior to entry and during an investigation. They can also allow investigators to compare past images with images taken more recently to ascertain changes that may have taken place since the initial documentation."[48]
Ground-based surveillance	Off-site surveillance – that is, the "surveillance of a site of interest at some agreed perimeter or distance, either by remote sensing or by visual inspection" – was identified as a potential means of assisting inspections. However, during VEREX it was also noted that "Optical and spectroscopic methods are not capable of identifying biological agents; generic bio-sensors have limited specificity (requires combination with sample collection)" and DNA probe sensors are not available for all biological agents.[49] Since VEREX, considerable advances have been achieved in off-site surveillance technology with a "very wide spectrum of techniques … that support the detection and identification of biothreats".[50] Examples include developments in Fibre Optic Biosensors to "detect target pathogens";[51] so-called E-nose systems that "can detect volatile organic compounds (VOCs) released by bacterial growth"; and disposable

[45] BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Summary Report, BWC/CONF.III/VEREX/8, 24 September 1993, https://undocs.org/BWC/CONF.III/VEREX/8, p. 13.

[46] BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Summary of the Work for the Period 24 May to 4 June 1993, BWC/CONF.III/VEREX/6, 8 June 1993, https://undocs.org/BWC/CONF.III/VEREX/6, pp. 195, 202.

[47] As Taylor has noted "Aerial drones, along with their operating personnel, would provide a disarmament and inspection organization with its own aerial surveillance capability making it less dependent on external support from member states". T. Taylor, "Lessons to Be Drawn from the Search for Iraqi WMD", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 180–183, https://doi.org/10.1080/00963402.2021.1941553.

[48] J. Revill and J. Borrie (eds.), "Science and Technology for WMD Compliance Monitoring and Investigations", WMD Compliance and Enforcement Series no. 11, UNIDIR, 2020, https://doi.org/10.37559/WMD/20/WMDCE11, p. 9.

[49] BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Summary Report, BWC/CONF.III/VEREX/8, 24 September 1993, https://undocs.org/BWC/CONF.III/VEREX/8, p. 14.

[50] O. Mattmann, "Detection and Identification Technologies for CBRN Agents", In M. Martellini and R. Trapp, 21st Century Prometheus, 2020, pp. 213–254, https://doi.org/10.1007/978-3-030-28285-1_11.

[51] Ibid. See also S.H. Ohk and A.K. Bhunia, "Multiplex Fiber Optic Biosensor for Detection of Listeria Monocytogenes, Escherichia coli O157: H7 and Salmonella Enterica from Ready-to-Eat Meat Samples", Food Microbiology, vol. 33, no. 2, 2013, pp.166–171, https://doi.org/10.1016/j.fm.2012.09.013.

TABLE 1. *continued*

Ground-based surveillance	matrix devices.[52] These monitoring technologies, still have particular limitations: for instance, they remain vulnerable to a range of environmental factors.[53] Yet it is also clear that the ability to detect biological weapons agents is quicker and more reliable than ever before, including in "real-time turnaround in the field".[54] On-site detection of dangerous biological agents has made major strides in recent years, particularly in the detection of novel infectious diseases, whether these are naturally occurring or human-made. Two technologies exemplify advances in this new field of "bio-monitoring". Next-generation sequencing combined with novel information technology allows, among other things, for possible attribution of genetic engineering.[55] Metagenomic sequencing allows the genetic sequencing of every pathogen residing in a single sample.[56] Unlike current PCR technologies, metagenomic sequencing allows pathogen-agnostic identification of novel infectious diseases. This is crucial to detecting biological weapon attacks with previously unknown engineered pathogens.
Auditing (off-site)	Auditing is the "critical examination, outside a facility boundary, in accordance with agreed standards and criteria, of documentary records, electronically-held data and manuals, to assess consistency with declared purposes and permitted activity". VEREX identified auditing as useful in developing a better picture of normal activity at a given facility in some circumstances.[57] However, VEREX also identified challenges for auditing posed by variations in data-collection standards and records. Although standards will always vary across the world, wider technological developments and changes to regulatory standards and data-gathering regimes (e.g. in "biological materials inventories" as required under ISO 35001 (2019)), are enhancing the information available through off-site auditing in at least some cases.[58] The increasing digitization of the biotechnology industry also presents new opportunities to remotely collect and track information related to compliance with the biological weapons regime.[59]

[52] Ibid.

[53] Remote monitoring especially of open spaces is not as effective as it should be and it is biased by a number of influencing factors such as velocity of winds, environmental temperatures, relative humidity, rain and snow, and atmospheric pollution, just to name a few. Ibid.

[54] P. Millett et al., "Feasibility of Onsite Verification", in J.P. Zanders (ed.), Verifying the BTWC in a Fast-Changing World (Forthcoming).

[55] E.C. Alley et al., "A Machine Learning Toolkit for Genetic Engineering Attribution to Facilitate Biosecurity", Nature Communications, vol. 11, 6293, 2020, https://doi.org/10.1038/s41467-020-19612-0.

[56] E.C. Carbo et al., "Coronavirus Discovery by Metagenomic Sequencing: A Tool for Pandemic Preparedness", Journal of Clinical Virology, vol. 131, 2020, 104594, https://doi.org/10.1016/j.jcv.2020.104594.

[57] BWC, Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint, Summary Report, BWC/CONF.III/VEREX/8, 24 September 1993, https://undocs.org/BWC/CONF.III/VEREX/8, p. 15.

[58] Millet notes, "regulatory regimes, including those with data gathering or reporting requirements, in both member countries and other states. Such regimes might include those responsible for consumer protections, health and safety in the work place, environmental protection, intellectual property, access and benefit sharing of biological resources, product labelling and authorization, field testing, use of genetically modified organisms, use of animals in research, as well as financial reporting, tax and revenues, etc". P. Millett et al., "Feasibility of Onsite Verification", in J.P. Zanders (ed.), Verifying the BTWC in a Fast-Changing World (Forthcoming).

[59] See Forman's contribution to the report following report for more on how this has worked in the chemical weapons regime. J. Revill and J. Borrie (eds.), Science and Technology for WMD Compliance Monitoring and Investigations, WMD Compliance and Enforcement Series no. 11, UNIDIR, 2020, https://doi.org/10.37559/WMD/20/WMDCE11.

Beyond the selected tools VEREX discussed in the 1990s, other scientific and technological developments are worth noting. First is the development of new technologies and approaches for disease surveillance and reporting. As the Council on Strategic Risks noted, "multiple new technologies and techniques have been developed that can be used to achieve true early warning of pathogens that risk affecting human populations. Many of them have also been scaled, reducing costs considerably".[60] In addition to the examples discussed in the entry on ground-based detection technologies in Table 1, there are new approaches to reporting novel disease outbreaks through systems such as the Program for Monitoring Emerging Diseases (ProMED).[61] These tools, combined with technological developments in areas such as metagenomics, are likely to improve further because of experience with COVID-19.

A second example of new tools is the role of open-source data in contributing to both the detection of disease outbreaks and investigations of allegations of biological weapons use or treaty non-compliance. Concerning disease outbreaks, the role of open-source data became more significant because of the international community's decision to include third-party reporting in the revised International Health Regulations (2005). In terms of investigations of alleged use, it is also notable that the OPCW's Fact-Finding Missions, when faced by practical scenarios of alleged use requiring investigation, augmented more traditional measures such as sampling with "several videos from social media websites and other open-source information".[62]

A third development is the emergence and growth of the field of microbial forensics – "a scientific discipline dedicated to analysing evidence from a bioterrorism act, biocrime, or inadvertent microorganism/toxin release for attribution purposes".[63] In response to the anthrax letter attacks in the United States in 2001, US authorities applied microbial forensics, and these techniques have since advanced considerably. Improvements in reference libraries and bioinformatics databases have helped, and they serve as critical resources for investigators applying microbial forensics.[64] As such, microbial forensics could help determine the provenance of future biological outbreaks, where evidence permits.[65] However, to be applicable in the context of the BWC, both the methods and the data derived from microbial forensics will need to be rigorously evaluated.[66]

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60 N.E. Bajema, W. Beaver and C. Parthemore, Toward a Global Pathogen Early Warning System: Building on the Landscape of Biosurveillance Today, Council on Strategic Risks, 2021, https://councilonstrategicrisks.org/wp-content/uploads/2021/07/Toward-A-Global-Pathogen-Early-Warning-System_2021_07_20-1.pdf, p. 5.

61 The Program for Monitoring Emerging Diseases (ProMED) is a programme of the International Society for Infectious Diseases (ISID). ProMED was launched in 1994 as an Internet service to identify unusual health events related to emerging and re-emerging infectious diseases and toxins. For more on this see M.P. Pollack, "Detection of Emerging Infections and Outbreaks – Reflections from ProMED-mail", 2018. For more on this see: https://promedmail.org/about-promed.

62 OPCW, Technical Secretariat, "Summary Report of the Work of the OPCW Fact-finding Mission in Syria Covering the Period from 3 May to 31 May 2014", S/1191/2014, 16 June 2014, https://www.opcw.org/sites/default/files/documents/Fact_Finding_Mission/s-1191-2014_e_.pdf, Annex 2, p. 7.

63 B.S. Budowle et al., "Building Microbial Forensics as a Response to Bioterrorism", Science, vol. 301, 5641, 2003, pp. 1852–1853, https://doi.org/10.1126/science.1090083.

64 M. Oliveira and A. Amorim, "Microbial Forensics: New Breakthroughs and Future Prospects", Applied Microbiology and Biotechnology, vol. 102, December 2018, https://doi.org/10.1007/s00253-018-9414-6.

65 K.L. Warmbrod, M. Montague and N.D. Connell, "Microbial Forensics: Detection and Characterization in the Twenty-first Century", In M. Martellini and R. Trapp, 21st Century Prometheus, 2020, pp. 357–370, https://doi.org/10.1007/978-3-030-28285-1_16.

66 C.A. Bidwell and R. Murch, "Use of Microbial Forensics Data in Scientific, Legal, and Policy Contexts", In B. Budowle, S. Schutzer and S. Morse (eds.), Microbial Forensics, 3rd edn., 2020, pp. 393–404, https://doi.org/10.1016/B978-0-12-815379-6.00026-X.

None of the developments discussed in this section alone provides a straightforward solution to enhancing compliance with the BWC. And any initiative to apply these advances will need to manage expectations about what can be achieved in terms of monitoring, particularly in terms of "small-scale activities in a distrusted country".[67] Yet these tools and technologies, in combination, have proven their value in other regimes. It has led some experts to argue that "using a variety of measures in concert, and by compiling numerous sources of information and signatures of unusual behaviour, it might be feasible to identify non-compliance with the BWC".[68]

To be effective, relevant technologies and methods will have to be validated in advance to ensure BWC States parties are satisfied these are acceptable for use in the regime. In this process, States parties may have reservations that go beyond the strictly technical dimensions of these technologies and encompass broader concerns about the manipulation or misuse of new technologies or sources of data for political ends. Proponents will need to be sensitive to such concerns.

Facilitating uptake of new technologies and methods for enhancing compliance is likely to require States making provision for at least three additional steps. First is some form of geographically representative scientific and technological review process capable of providing credible, objective technical assessment of the various technologies in support of compliance monitoring and investigations.[69] The second requirement is some process of testing any mechanisms designed to investigate compliance with the BWC, including through laboratory tests and field exercises. The third is strengthened engagement and knowledge exchange between BWC States parties on the one hand and industry, academic and international organizations on the other.[70] This third step would both enable a connection to cutting edge science and facilitate stakeholder cooperation in the optimisation of any compliance measures.

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67 Å. Sellström, "UNSCOM: A Successful Experiment in Disarmament", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 177–79, https://doi.org/10.1080/00963402.2021.1941543.

68 P. Millett et al., "Feasibility of Onsite Verification", in J.P. Zanders (ed.), Verifying the BTWC in a Fast-Changing World (Forthcoming).

69 For more on some form of science and technology review mechanism see J. Revill, A. Anand and G. Persi Paoli, Exploring Science and Technology Review Mechanisms Under the Biological Weapons Convention, UNIDIR, 2021, https://doi.org/10.37559/SECTEC/2021/SandTreviews/01.

70 As Taylor notes "There is a real challenge in maintaining a standing organization that is up to date on developments in the relevant sciences and their commercial applications. This is a particular challenge in biotechnology and the life sciences. It would be important to draw on people from private industry or academia so they can be brought into the small standing organization when needed." T. Taylor, "Lessons to Be Drawn from the Search for Iraqi WMD", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 180–183, https://doi.org/10.1080/00963402.2021.1941553.

3 WIDER CHANGES SINCE 2001

In hindsight, VEREX and the start of the Ad Hoc Group negotiations took place in during a window of opportunity for achieving new multilateral arms control, disarmament and non-proliferation agreements that opened in the few years following the end of the Cold War in 1989. This period also saw the conclusion of negotiations on the 1993 Chemical Weapons Convention and the 1996 Comprehensive Nuclear-Test-Ban Treaty. Sadly, in hindsight, this period did not last long; the window swung closed before the BWC's compliance regime could be strengthened.

3.1 CHANGING GEOSTRATEGIC CONTEXT

Over the last 20 years, the wider political and strategic context has become much less conducive to multilateral disarmament and arms control efforts than the golden post-Cold War period, and in the last decade the environment has become notably more hostile and difficult. This trend toward competitive multipolarity shows no sign of reversing. Russia's invasion of Ukraine in February 2022, as this report was being completed, has exacerbated tensions between Russia and the West, and is likely to compound difficulties across the board for multilateral processes for some time to come, including in the BWC setting.

FIGURE 2. *Mapping BSL4 facilities around the world*

Source: *https://www.globalbiolabs.org/map*

When the Cold War ceased, the United States lacked a direct peer competitor in the biotechnology domain. Today, against a background of peer-level strategic rivalry between the United States, China, and the Russian Federation, these States, along with a growing number of others around the world, have considerably enhanced their capacity for research and development in the life

sciences. This is reflected in the surge of new biological laboratories, including Biosafety Level 4 (BSL-4) facilities, globally over the last decade (see Figure 2).[71] Filippa Lentzos and Gregory Koblentz estimated there are "nearly 60 maximum containment facilities that are planned, under construction, or in operation around the world", many of which are small facilities under 200 m^2.[72] As a result of the pandemic, the number of laboratories may increase further in the coming years as States around the world seek to bolster scientific capacity to detect and respond to outbreaks of disease.

This increased biotechnology activity around the globe has not always been matched by an increase in transparency in State-funded biological research activities. In the current period, lack of transparency creates fertile grounds for biological weapons-related accusations, which continue to be made periodically between BWC State Parties,[73] including most recently at the second part of the Preparatory Committee for the Ninth Review Conference in April 2022. As Carmen Wunderlich and colleagues noted of these kinds of allegation, "Without effective transparency and verification measures, such claims and denials are hard to confirm or refute independently".[74] As in the past, a risk remains that heightened anxiety over adversarial research and development could stimulate a biological arms race.[75]

3.2 COMPLIANCE CHALLENGES

Changes in the underlying geopolitical context affect the politics of allegations concerning weapons of mass destruction (WMD). Three examples from the last two decades illustrate this. The first was the invasion of Iraq by the United States, the United Kingdom, and others in 2003, which they rationalized on the basis that Iraqi dictator Saddam Hussein was still pursuing active WMD programmes – something ultimately not substantiated. The 2003 war in Iraq and its aftermath "damaged the brand" for intrusive arms control measures and has exacerbated the scepticism of some governments and experts about subsequent WMD-related allegations.

Second, chemical weapons use in Iraq, Malaysia, the United Kingdom, and the Syrian Arab Republic over the last decade indicates that chemical weapons still have some utility for certain States in the 21st century. These incidents of use also challenged the chemical weapons regime. Although the OPCW demonstrated remarkable innovation in disposing of Syria's declared chemical arms stockpiles, the subsequent use of chemical weapons in Syria highlighted the difficulty in eradicating all such capabilities and eliminating the residual capacity to make them.

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[71] J. Rodgers, F. Lentzos, G.D. Koblentz and M. Ly, "How to Make Sure the Labs Researching the Most Dangerous Pathogens are Safe and Secure", 2 July 2021, Bulletin of the Atomic Scientist, https://thebulletin.org/2021/07/how-to-make-sure-the-labs-researching-the-most-dangerous-pathogens-are-safe-and-secure.

[72] F. Lentzos and G.D. Koblenz, "Mapping Maximum Biological Containment Labs Globally", King's College London, May 2021, https://static1.squarespace.com/static/6048d7a0e9652c472e619f6f/t/60ae71cea2219b008f29d4ca/1622045135314/Mapping+BSL4+Labs+Globally+EMBARGOED+until+27+May+2021+1800+CET.pdf.

[73] See, for example, C.A. Ford, United States Assistant Secretary of State for International Security and Non-Proliferation, "Our Global Partnership against Chemical Weapons Abuses", Remarks, Plenary Meeting, Global Partnership Against the Spread of Weapons and Materials of Mass Destruction, 18 November 2020, https://2017-2021.state.gov/our-global-partnership-against-chemical-weapons-abuses/index.html. See also Ministry of Foreign Affairs of the Russian Federation, "Comment by the Information and Press Department on developments involving the Richard Lugar Centre for Public Health Research in Georgia", 26 May 2020, https://mid.ru/en/foreign_policy/news/1433686.

[74] C. Wunderlich, H. Müller and U. Jakob, WMD Compliance and Enforcement in a Changing Global Context, UNIDIR, WMD Compliance and Enforcement Series no. 11, 2021, https://doi.org/10.37559/WMD/21/WMDCE02, p. 25.

[75] G. Cross, "Wrestling with Imponderables: Assessing Perceptions of Biological-Weapons Utility", Nonproliferation Review, 2021, https://doi.org/10.1080/10736700.2020.1858621.

Further innovations – the OPCW Fact-Finding Mission (FFM) and Declaration Assessment Team (DAT), the United Nations–OPCW Joint Investigative Mechanism (JIM) and, more recently, the OPCW Investigation and Identification Team (IIT) – have established the facts surrounding chemical weapons allegations, resolved some uncertainties in declarations or even identified the perpetrators of chemical attacks. However, mechanisms, such as the DAT are yet to certify the accuracy of the Syrian declaration and enforcement of the CWC remains elusive. This is further complicated by mis- and dis-information activities related to chemical weapons development and use.[76] These experiences in the chemical weapons disarmament regime illustrate the kinds of challenge foreseeable for BWC compliance mechanisms, even if the mechanisms could have been elaborated along the lines envisaged in the Ad Hoc Group's draft protocol to a commensurate degree.

The third example concerns the Russian Federation's recent allegations of "military biomedical activities… carried out in the biological laboratories in the territory of [Ukraine] with the support of the Defense Threat Reduction Agency (DTRA) of the U.S. Department of Defense … in violation of Articles I and IV of the BTWC".[77] The Russian allegations, made both in the Security Council and in the BWC setting in 2022, coincide with its military invasion of Ukraine and, as such, to most observers resemble a post facto rationalization. Ukraine, along with the US and Western European States also involved in cooperation with Ukrainian laboratories, strenuously deny Russia's allegations and have criticised what they regard as their flimsy nature. Whatever the real intention or veracity of Russian allegations, they underline the value of functioning clarification and compliance mechanisms in the BWC.

3.3 BIOTERRORISM AND SMALL-SCALE COVERT BIOLOGICAL WEAPONS

The 11 September 2001 terrorist attacks in the United States and subsequent anthrax letters drew the attention of many governments to a wider spectrum of biological risks. Throughout the BWC's prior history – including VEREX and the Ad Hoc Group negotiations – States were primarily concerned with State-based bioweapons programmes. Indeed, the draft BWC protocol was primarily designed to detect clandestine, government-run programmes aspiring to "militarily significant" biological weapons. However, the events of 2001 illustrated both the feasibility and potentially far-ranging and severe effects of acquisition and use of bioweapons by non-State actors.

Concern about bioterrorism was compounded by revelations about earlier, covert State biological weapons programmes designed for targeted purposes, including covert localized attacks, sabotage and assassinations, that fall short of mass casualties and disruption.[78] More recent chemical attacks in Syria have served as further indications of the harm and fear that biological weapons use might cause, if used for these purposes. It also means caution is needed in making

[76] R. Trapp and C. Tang, Enhancing Compliance Management and Enforcement in the Regime Prohibiting Chemical Weapons, UNIDIR, 2021, https://doi.org/10.37559/WMD/21/CWC/01.

[77] See Russian Federation, "Statement by the Delegation of the Russian Federation at the Second Session of the Preparatory Committee for the Ninth Review Conference of the States Parties to the Biological and Toxin Weapons Convention (BTWC)", 4 April 2022. https://documents.unoda.org/wp-content/uploads/2022/04/Russia_5_EN_for-publishing.pdf.

[78] See, for example, accounts of South Africa's Project Coast: C. Gould and P. Folb, Project Coast: Apartheid's Chemical and Biological Weapons Programme, UNIDIR, 2002.

assumptions about the purposes of biological weapons programmes, or that all States really believe biological weapons have little or no perceived military utility. As Seth Carus remarked:

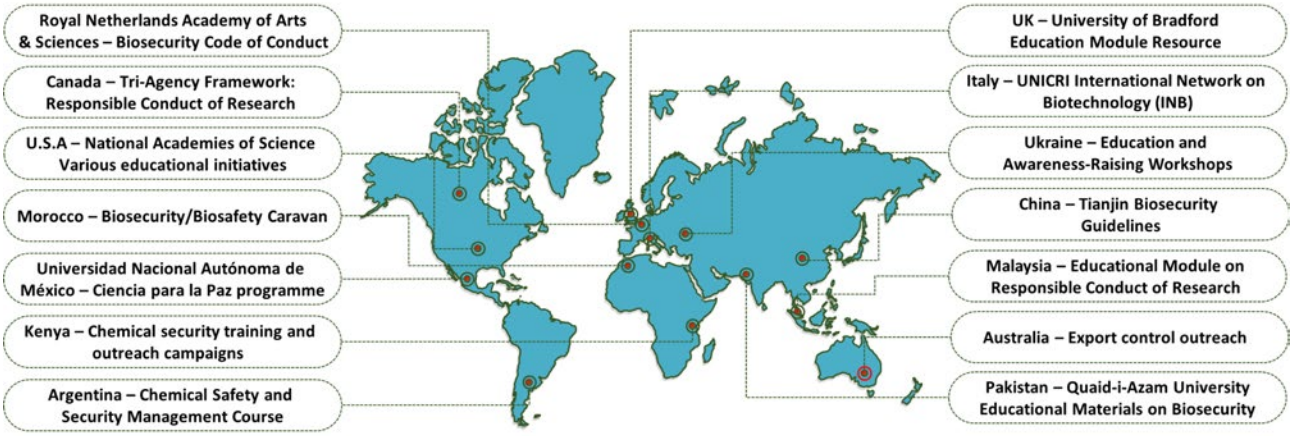
> *"most [biological weapons] programs seem to have generated capabilities more appropriate for use in small-scale covert operations intended to affect small numbers of people; few have created what might be considered 'militarily significant' capabilities at all".*[79]

With heightened geostrategic tensions, the focus of concern about biological weapons may be now moving back towards State-based programmes. But bioterrorism is – and will probably remain – a major concern for all BWC States parties. To the contemporary reader, the minimal attention that the VEREX report and the draft protocol texts gave to bioterrorism and biological weapons designed for small-scale attacks likely seems inadequate by today's standards.

3.4 FROM GOVERNMENT TO GOVERNANCE

The Ad Hoc Group's collapse and the draft protocol's demise in 2001 led to acrimony among some BWC States Parties. Emerging concerns over bioterrorism had a positive effect in that it brought them somewhat closer together to tackle this topic. Developing a collective approach to the shared threat of bioterrorism was probably the key factor in the success of the first BWC intersessional work programme (2003–2005) – a success that was not generally predicted. The adoption of United Nations Security Council resolution 1540 in 2004, which obliged all United Nations Member States to take specific actions to reduce the risks of WMD terrorism, further reinforced this orientation.

FIGURE 3. *Illustrative examples of wider biosecurity governance tools*



The BWC's shift in focus from State-based bioweapons programmes to bioterrorism stimulated a growing role for non-State actors in industry and academia in the governance of biological risks. Such actors have collectively fed into the development of a web of measures designed to prohibit and prevent biological weapons (see Figure 3 for illustrative examples).[80] These draw in a range of actors operating at different levels, "from the individual to the international".[81] Indeed, while the BWC

[79] W.S. Carus, "A Century of Biological-Weapons Programs (1915–2015): Reviewing the Evidence", Nonproliferation Review, vol. 24, nos 1–2, 2017, pp. 129–153, https://doi.org/10.1080/10736700.2017.1385765.

[80] See ICRC, "Biotechnology, Weapons and Humanity – Workshop 4", 28th International Conference of the Red Cross and Red Crescent, Geneva, 2–6 December 2003, https://www.icrc.org/en/doc/resources/documents/misc/5udjf5.htm.

[81] J. Littlewood, "Managing the Biological Weapons Problem: From the Individual to the International", Weapons of Mass Destruction Commission, 2004, https://eprints.soton.ac.uk/39639.

in the VEREX period could have been crudely characterized as "States watching States", today the situation could reasonably be described as "States and other actors watching States and other actors".

Partly through the BWC intersessional work programme, scientific and professional organizations and medical associations have become more involved in managing biological risks – including deliberate use of biological agents as weapons. National, regional, and international biosafety associations have embarked on developing and implementing standards; and international standards such as ISO 35001 on Biorisk management for laboratories and other related organisations, are now widely accepted and used.[82] Codes of conduct, codes of practice, and similar instruments, have been widely adopted, although their effectiveness and durability is not always clear.

3.5 COVID-19

The COVID-19 pandemic is a more recent, and dramatic, development, one that as of writing, seems far from over. Scientists, public health authorities, security analysts and others had warned for many years of the potential for such a globally disruptive and destructive pandemic. In hindsight, the SARS, MERS and Ebola outbreaks earlier this century were near misses. Collectively, the international community managed some modest steps towards the prevention and management of a pandemic scenario. Yet it was still a colossal shock when a pandemic happened in 2020. The pandemic exposed desperate shortcomings in international disease surveillance and response. COVID-19 has already killed millions of people, left millions more with long-term debilitating symptoms, and has cost the global economy trillions of dollars.

The overall global public policy response to pandemics like COVID-19 is beyond the scope of this paper. Nevertheless, it is already clear that the pandemic substantially alters the political context for the BWC regime. Public perceptions have shifted and suspicion between some governments has grown, all amidst a wider erosion of confidence in expertise and science in an era of heightened fake news and mis- and dis-information. Inequitable distribution of, and access to, COVID-19 vaccines and novel anti-viral treatments has heightened sensitivities and long-simmering resentments about the unrestricted exchange of scientific and technological advances for peaceful purposes, especially among developing countries. This is influencing the discourse about the implementation of BWC Article X (see section 4).

[82] ISO, "ISO 35001:2019 - Biorisk management for laboratories and other related organisations", International Organization for Standardization, 2019. https://www.iso.org/standard/71293.html.

3.6 DUAL-USE RESEARCH OF CONCERN

Finally, the growing salience of "dual-use research of concern" is also relevant to the BWC's compliance discourse. There has long been debate over the extent to which the BWC prohibits bioweapons-related "research". In contrast to development, production or stockpiling, "research" is not explicitly mentioned in BWC Article I.

The possibility that publication of well-intentioned, peaceful research, conducted in accordance with all the appropriate biosafety and biosecurity requirements, could assist a third party to develop biological weapons rose to public prominence once again in 2011. This was due to controversy over viral gain-of-function research conducted in the Netherlands and the United States.[83] While the issue has been discussed in the BWC (and elsewhere), and various ad hoc measures have been adopted in the scientific community (see for example Figure 3 above), this type of activity remains largely ungoverned in any formal sense.

Yet for confidence in compliance with the BWC it is important to govern and build oversight of dual use research. Piecing together a picture of non-compliance based on various forms of evidence – whether samples, documentation, patterns of behaviour, witness testimony and other evidence – does not in itself settle matters of compliance. This reflects the reality that ensuring confidence in compliance is a political process, not just a technical one, that draws from a wide range of validated sources, some of which may not necessarily be directly connected to the BWC in its current form and may be subject to misinformation and contestation. Nevertheless, the point here is that targeted uptake of new technologies, tools and approaches could help verification, especially in the context of future agreements between BWC States parties in terms of how they will handle matters of suspected or alleged non-compliance.

[83] See, for example, National Research Council, "Potential Risks and Benefits of Gain-of-Function Research: Summary of a Workshop", 2015.

4 CONTINUITY IN THE BWC

The views of governments and other stakeholders vary on whether resurrecting a legally binding "verification protocol" like the one developed in the Ad Hoc Group is feasible or desirable. In the face of the challenges and changes described above, it is unclear whether this approach would be effective. Nevertheless, a striking element of continuity from the VEREX period to today is the sustained interest from many quarters in strengthening the BWC with measures to enhance confidence in compliance. Setting compliance to one side, as the resumed Fifth Review Conference in 2002 more or less did, has not made the issue go away.[84] For all the BWC's normative success, its lack of machinery for monitoring compliance and for dealing with non-compliance concerns remains a problem in the eyes of many of its States parties. Although the debate in BWC meetings about compliance and verification since 2002 has often seemed stale, repetitive, and unproductive, the fact that it has persisted over such a long period does point to a genuine need – a need to enhance the level of assurance that the BWC's prohibitions are being complied with, but in a manner that is practically and politically feasible.

4.1 TRUST DEFICIT

Deepening distrust between the leading military powers about each other's intentions and strategic capabilities, including in the biological weapons realm, is an obvious hurdle. However, this is not new problem. In the past, distrust was a prime motivation for all kinds of multilateral arms control and disarmament measures as States sought to improve transparency and limit their strategic competition or channel it in less risky and destabilizing directions. Indeed, the BWC was itself a product of this process in the early 1970s, with the confidence-building value of its prohibitions between distrustful superpowers felt to outweigh the obvious weakness of a regime without a verification component. Today, as in the 1990s, we can see the limits of that approach. It underlines the need for the BWC regime as whole to reassess what it is possible to do to narrow the deficit of trust concerning compliance in the current difficult, distrustful environment.

In recent times, bitter controversies in the OPCW context over chemical weapons use in Syria and elsewhere have underlined the problem of the perceived impunity of those responsible. Questions over the degree to which the most powerful can be held to account in international forums have always featured in international arms control, disarmament, and non-proliferation regimes, and indeed in multilateral regimes more broadly. Article VI of the BWC, for example, provides for allegations of non-compliance to be referred to the United Nations Security Council, but it has never been clear how this would work if the accused State party were a permanent member of the Council and thus able to veto proceedings or findings.

Nevertheless, even the most powerful States sometimes find it to be in their interest to pursue their claims, suspicions and grievances through multilateral mechanisms, or accept their adjudication, even if these rulings do not always go their way. For less powerful States, the appeal of formal multilateral structures and legally binding mechanisms remains as important as ever. Multilateral mechanisms still provide a means of rendering the international playing field at least somewhat less drastically tilted, even if still far from level. Most States – including

[84] See J. Revill et al., Preparing for Success at the Ninth Biological and Toxin Weapons Convention Review Conference: A Guide to the Issues, UNIDIR, 2021, https://doi.org/10.37559/WMD/21/BWC/01.

the most powerful – recognize the benefits of multilateral rules-based structures and accept that these are non-zero-sum in the longer run, especially as norms of acceptable international behaviour take hold.

4.2 INTERNATIONAL COOPERATION

A further element of continuity from the 1990s is the tension between developed and developing BWC States parties over access to biological technology. This tension is intrinsic to the text of the BWC itself – between Article III, which prohibits any assistance or encouragement to acquire biological weapons, and Article X, which obliges BWC States parties to cooperate, where possible, in contributing to biological science and technology for peaceful purposes and requires the BWC to be implemented in a way that avoids hampering States parties' economic and technological development.[85] Article III is typically interpreted as requiring, or at least justifying, national export control measures. Some BWC States parties have gone further by cooperating in strategic export regimes with limited membership such as the Australia Group.

Many developing States party to the BWC have long complained that such measures impede their access to needed biological technology. In the BWC Ad Hoc Group negotiations, a trade-off was implicitly and generally recognized: progress on verification, compliance or national implementation should be matched by measures to strengthen the implementation of Article X. The Ad Hoc Group mandate, for example, was an exhaustively negotiated balance between these interests, which in the conditions of the mid-1990s were seen as competing.

While this tension still exists, there has been significant evolution, in part due to the early success of the first intersessional work programme (2003–2005) in finding common ground for most States parties on improving BWC implementation. Exogenous developments, such as United Nations Security Council resolution 1540, have also played their part. UNSCR 1540 obliged States to develop and maintain effective national controls.[86] As mentioned above, this was largely driven by the post-2001 concerns about bioterrorism, but this has had an indirect effect on promoting BWC implementation. As the United Nations Secretary-General, Kofi Annan, put it at the Sixth Review Conference, in 2006:

> *"building public health capacities can strengthen safeguards against bioterrorism. And being better prepared to deal with terrorism can mean better public health systems overall. Similarly, the availability of training and technology is crucial to improving laboratory safety and security, and making labs safe and secure encourages cooperation and creates opportunities for development."*[87]

This more cooperative perspective facilitated some useful innovations and forms of collaboration in the course of the BWC intersessional work programmes. It should be noted, however, that the underlying political tension soon re-emerged whenever larger decisions were at stake at Review Conferences. Just as happened at the Eighth BWC Review Conference, the topic of access to

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85 On implementation of Article X, see J. Revill and M. Garzón Maceda (eds.), "Options for Article X of the Biological Weapons Convention", UNIDIR, 2021, https://doi.org/10.37559/WMD/21/BWC/04.

86 See UN Security Council, "Resolution 1540 (2004)", S/RES/1540, 28 April 2004. Para 3. d.

87 UN Secretary-General, "Secretary-General's remarks to the Sixth Review Conference of the Biological Weapons Convention", 20 November 2006, https://www.un.org/sg/en/content/sg/statement/2006-11-20/secretary-generals-remarks-sixth-review-conference-biological.

biotechnology is likely to arise again at the Ninth Review Conference, potentially even more acutely because of public health challenges and vaccine inequality that the COVID-19 pandemic has exposed.[88] Unresolved grievances around Article X present a compliance concern in and of themselves, in addition to weakening incentives to participate in any future verification regime.[89]

4.3 DEFINITIONS

As well as continuity in these political factors, there are also some structural challenges relating to the BWC itself and the nature of the bioweapons risk that remain familiar from the VEREX period. The first of these is the way in which the BWC defines a biological weapon: the so-called "general purpose criterion" of Article I, which prohibits "microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes". Rather than list specific agents or specify permitted quantities, this prohibition essentially governs intent: possession of any biological agent, in any quantity, is legal only if justified for peaceful purposes.

This has proved to be a remarkably comprehensive and future-proof formulation. But the general-purpose criterion has the disadvantage of being difficult to verify. Whatever technological advances may be made in terms of detecting and identifying biological agents, these will still only be individual pieces of the compliance jigsaw puzzle. They do not necessarily complete the whole puzzle to reveal the full picture of intent, which is a pattern much more difficult to establish.

4.4 BLURRED LINES BETWEEN DOMAINS

Another enduring challenge since the 1994 VEREX report is the complex interrelationship and blurred boundaries between bioweapons risks and other biological risks such as naturally occurring disease outbreaks and accidental releases. Disease outbreaks, including COVID-19, illustrate the difficulty of distinguishing between natural, accidental, and deliberate outbreaks of disease, and which could be encountered in the realm of BWC compliance. Meanwhile, a coordinated international public health response may be required long before it is clear whether the situation concerns the BWC. Yet, many BWC States parties have, at least until now, insisted on a strict separation between global public health governance (which is seen as the exclusive domain of the World Health Organization (WHO)) and bioweapons governance (the exclusive domain of the BWC).

[88] R. Baldwin and S.J. Evenett (eds.), Covid-19 and Trade Policy: Why Turning Inward Won't Work, CEPR and VoxEU.org, 2020; in particular the chapters S. J. Evenett, "Flawed Prescription: Export Curbs on Medical Goods Won't Tackle Shortages"; and B. Hoekman, M. Fiorini and A. Yildirim, "Covid-19: Export Controls and International Cooperation".

[89] As Smidovich notes: "As well as the overall purpose and inspector access levels, you also need to think about conditions for participation in verification regimes – considering, for example, whether participation could be linked to some sort of favor or benefit, such as lifting potential sanctions". H. Wilson and N. Smidovich, "Perspectives on UNSCOM and UNMOVIC: An Interview with Nikita Smidovich", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 184–87, https://doi.org/10.1080/00963402.2021.1941564.

This separation of the global public health and bioweapons governance domains is somewhat artificial as pathogens neither know nor care whether they have emerged naturally, accidentally, or deliberately. Arguably, such separation hampers the development of a coherent and comprehensive approach to effective global governance of the full spectrum of biological risks, leading to both overlaps and gaps. For example, as discussed in section 3.6, the controversy in 2011 about gain-of-function research and other dual-use research of concern revealed a disturbing gap in the monitoring and controlling of potentially dangerous biological research taking place across national boundaries (e.g. research funded by one country, undertaken in another and published in a third). Ten years later, this gap has yet to be filled in any comprehensive, systematic way.

Since the emergence of the COVID-19 pandemic the global public health system has been stress tested in a way in which many shortcomings have come to light in terms of how States and the supporting system of international organizations coordinate and cooperate. This has led to initiatives focused on improving international pandemic preparedness and response, including calls for a new global compact. Yet for all the interest in a pandemic treaty, it is unclear how far this initiative, which is being pursued in the WHO setting, will join up with the parts of the multilateral system relevant to non-natural disease outbreak scenarios. As a practical matter, improved global disease surveillance and response mechanisms are likely to have utility in detecting deliberate disease outbreaks too, and perhaps even accidental releases – although, as mentioned, it may not be immediately established as such. It points to a need for a coherent approach toward blurred lines scenarios that currently does not appear to be the focus of much attention.

5 MOVING FORWARD

Considering the change and continuity evident in the BWC regime over the last two decades, what can its States parties usefully do to address compliance with the Convention today? There are certain signs in the BWC that, given recent developments, a greater recognition and maybe even broader flexibility exists on such measures.[90] To that end, States parties seeking to build confidence in compliance with the BWC could consider three strategies discussed below.

1. Systematically re-examine and evaluate compliance and verification tools

Science and technology have changed since verification technologies were last discussed in the earlier 1990s. As such, and without prejudice to a particular outcome, a systematic, multilateral process to evaluate the potential for useful evaluation tools to monitor compliance in the BWC is arguably long overdue.

One way for BWC States parties to undertake a fresh evaluation is to establish a new process like VEREX. Akin to an open-ended working group, such a "VEREX 2.0", would have to be open to all States parties and draw upon expertise from a variety of sources, including international organizations, the scientific community, academia, industry, and civil society. The mandate for this process could even be based on the original VEREX mandate, with its overall purpose "to identify and examine potential verification measures from a scientific and technical standpoint".[91] It might be broadened as appropriate to include verification measures that are relevant to 'classical' state warfare biological weapons scenarios, but also bioterrorism and the surreptitious small-scale use of biological weapons, as well as investigating suspicious outbreaks of disease.

Thus, while the original VEREX mandate tasked the group with seeking to identify measures which could determine:

- Whether a State party is developing, producing, stockpiling, acquiring or retaining microbial or other biological agents or toxins, of types and in quantities that have no justification for prophylactic, protective or peaceful purposes.

- Whether a State party is developing, producing, stockpiling, acquiring or retaining weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.[92]

[90] For instance, see "Statement and Right of Reply by the U.S. Special Representative for the Biological Weapons Convention Kenneth D. Ward, Second Preparatory Committee Meeting for the Ninth Review Conference for the Biological Weapons Convention, April 4, 2022", https://documents.unoda.org/wp-content/uploads/2022/04/US-Statement-and-Right-of-Reply-to-BWC-PrepCom-under-General-Exchange-of-Views-4-April-2022.pdf.

[91] The VEREX mandate is contained in the Article V section of the BWC, Third Review Conference, Final Declaration, BWC/CONF.III/23, 27 September 1991, https://docs-library.unoda.org/Biological_Weapons_Convention_-_Third_Review_Conference_(1991)/BWC_CONF.III_23.pdf, Part II, p. 16.

[92] Ibid., p. 17.

A mandate for VEREX 2.0 might also consider measures which could determine, for example:

- Whether a particular facility, person or group is developing, producing, stockpiling, acquiring, or retaining microbial or other biological agents or toxins, of types and in quantities that have no justification for prophylactic, protective or peaceful purposes.
- Whether an outbreak of disease or other adverse health event, including the illness or death of one or more humans, animals, or plants, is due to activity prohibited to a State party under the BWC.
- The origin or means of production, transfer and delivery of a biological agent or toxin that has been used for hostile purposes or in armed conflict.
- Possible objective thresholds at which these kinds of measure would appropriately be enacted under the BWC; this is a separate matter from the decision-making process through which this would occur.

The elements above are not an exhaustive list, and there are many possible formulations that States parties could consider to ensure a sufficiently wide-ranging and comprehensive mandate for the exercise.

The assessment of compliance monitoring and verification technologies undertaken in this VEREX 2.0 could revisit the verification tools discussed in the past. It could also look at the potential of emerging tools and approaches, including bioforensics and open-source methods. There is much that could be gleaned from the work of other organizations in such an exercise. One example of this is the OPCW Scientific Advisory Board's Temporary Working Group on Investigative Science and Technology, which provides an overview of the potential of some relevant technologies. Another is the International Atomic Energy Agency's Symposium on International Safeguards and its activities under Programme 93+2, which provides some insights into processes to assess and field trial technologies.[93] Facts-based exploration through a VEREX 2.0-type process could benefit the collective thinking of BWC State parties whatever their current position on verification by focusing their attention on realistic avenues for future cooperation to strengthen compliance with the Convention.

2. Review and develop channels for raising and responding to compliance concerns

Even the most modern and effective verification technologies and investigative techniques will be of little use if there is no clear and accepted path for invoking and applying them in specific, concrete situations. The formal channels for raising and responding to compliance concerns, therefore, need careful attention from States parties, especially if these are supposed to function effectively in situations of high political tension, disputed circumstances and divided international opinion – that is to say, in most of the plausible scenarios involving alleged violations of the BWC.

[93] R. Hooper, IAEA Development Programme for a Strengthened and More Cost Effective Safeguards System, International Atomic Energy Agency (IAEA), 1994, https://inis.iaea.org/collection/NCLCollectionStore/_Public/26/008/26008772.pdf?r=1.

[94] European Union, "Enhancing the Effectiveness of the Consultative Provisions of Article V of the Biological and Toxin Weapons Convention", BWC/CONF.VIII/WP.16, 31 October 2016, https://undocs.org/BWC/CONF.VIII/WP.16.

The starting point could be the reaffirmation and development of procedures for consultation and clarification pursuant to Article V that were elaborated by previous BWC Review Conferences.[94] States parties could also usefully explore the potential for consultation and co-operation "through appropriate international procedures within the framework of the United Nations and in accordance with its Charter" as stipulated in the second sentence of Article V.

In addition to reviewing and updating Article V, States parties could also consider developing more structured procedures relating to Article VI, setting out exactly how allegations of non-compliance, including alleged development or production, should be referred to the United Nations Security Council.[95] This might involve various intermediate steps of clarification and validation – perhaps including the kind of legally binding investigation mechanism envisaged in the draft Ad Hoc Group protocol. There is, of course, much less scope for BWC States parties to determine how the Security Council should ultimately deal with any such matter, although a consensus recommendation or request from a BWC Review Conference would presumably carry some weight in persuading the Council to adopt a certain approach or set of guidelines.

Regardless of whether it involves a new legally binding instrument, any negotiation around these issues is likely to be difficult, particularly when it comes to factors such as the determination of a trigger (or triggers) for any facility investigation, addressing concerns over access and confidentiality, and reaching agreement around suitable methods and guidelines for any investigation. Moreover, effectively addressing an operational gap around facility investigations or investigations of suspicious disease outbreaks (if not alleged use, which the United Nations Secretary-General's Mechanism covers) would require considerable effort as it entails developing geographically and technically diverse pools of expertise and calibrating laboratory networks. However, forging common understandings around expectations and processes in advance of any future event is preferable to ad hoc responses.[96] It could perhaps begin with a politically binding commitment from BWC State parties to accept investigations in the event of an allegation coupled with a technical review of the science and technology of relevance discussed below.

There is also a broader question of whether and how actors other than BWC States parties might be involved in raising and responding to compliance concerns. There are different channels for this, including, but not limited to, the BWC. The landscape of research and development in the life sciences has evolved considerably since VEREX. The number of entities now publishing and patenting research that could be exploited for hostile purposes (see Figure 1 above) is now an order of magnitude greater than the mid-1990s. Although technological opportunities to detect and investigate non-compliance have doubtless emerged, human intelligence remains critical, particularly when it comes to determining intent.[97] Individuals working in the life sciences need to be aware they have a stake in the BWC's success and orient themselves toward practical steps

[95] This was discussed during the second session of the Ninth Preparatory Committee. See the Vice Chair's summary in Italy and Romania, "Vice-Chairs' letter", 29 April 2022, https://documents.unoda.org/wp-content/uploads/2022/04/2022-0429-VCs-letter-to-SPs-PrepCom-record.pdf para. 12.

[96] As Trapp notes of recent efforts to investigate allegations of chemical weapons use in Syria: "Reliance on ad hoc mechanisms can create vulnerabilities for the Technical Secretariat and force it into a position where it has to defend its technical methods and conclusions against criticism by governments that have a strong interest in the case under investigation." R. Trapp, Compliance Management under the Chemical Weapons Convention, WMD Compliance and Enforcement Series no. 3, UNIDIR, 2019, https://doi.org/10.37559/WMD/19/WMDCE3.

[97] P. Millett et al., "Feasibility of Onsite Verification", in J.P. Zanders (ed.), Verifying the BTWC in a Fast-Changing World (Forthcoming).

they can take to uphold its obligations in line with their ethical and moral responsibilities as scientists or medical practitioners. To this end, new channels could be considered for scientists and other stakeholders to raise any concerns with BWC States parties or with other inter-governmental bodies (e.g. the Security Council or WHO). This could complement wider initiatives designed to raise awareness of dual-use challenges, through for example codes of conduct, something taken forward recently through the Tianjin Biosecurity Guidelines for Codes of Conduct for Scientists.

3. Develop a supportive environment and "compliance ecosystem"

The above two strategies cannot be pursued effectively in isolation: if they are to provide real and sustained improvements, they need to be supported by increased institutional support beyond the BWC's current three-person Implementation Support Unit (ISU) and in the broader context of the Convention and its related communities. There are several things that States parties could do to help develop a political and diplomatic environment that supports efforts to improve compliance-monitoring and verification capabilities, including:

- **Ensuring support for the implementation of Articles VII and X.** The measures above will attract greater multilateral support if they form part of a balanced package of measures that appeals to all BWC States parties. Measures to enhance the provision of assistance under Article VII, such as the assistance database proposed by France and India,[98] could minimise the consequences of biological weapons should they ever be used. In terms of Article X, any moves to strengthen compliance monitoring and build verification mechanisms are likely to be more effective on both political and technical levels if they increase international cooperation and exchange in biological science and technology and help to build technical capacity in developing countries. Various proposals have been made in this regard, and one readily accessible source in this regard is UNIDIR's paper on "Options for Article X of the Biological Weapons Convention", which contains a range of ideas to increase the effectiveness of Article X. These include, for example, the idea of establishing some form of cooperation "entity" to examine and explore the extent and magnitude of the problem and recommend specific measures to enhance international cooperation.[99]

- **Establishing some form of science and technology review mechanism.** To monitor risk and opportunities that arise from developments in life science and related disciplines, States parties should consider establishing a mechanism to assess the implications of advances in science and technology more systematically.[100] This idea has, of course, been widely discussed in respect to many aspects of the BWC, including facilitating knowledge transfer around science and technology and improving implementation of Article X. Such a mechanism could also conceivably contribute to supporting compliance and verification efforts.

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98 India and France, "Proposal for the Establishment of a Database for Assistance under Article VII of the Biological and Toxin Weapons Convention: Specific Pending Issues and Way Forward for the Operationalization of the Proposal", BWC/MSP/2020/MX.4/WP.3, 17 August 2021, https://undocs.org/en/BWC/MSP/2020/MX.4/WP.3.

99 J. Revill and M. Garzón Maceda (eds.), Options for Article X of the Biological Weapons Convention, UNIDIR, 2021, https://doi.org/10.37559/WMD/21/BWC/04.

100 See for example J. Revill, A. Anand and G. Persi Paoli, Exploring Science and Technology Review Mechanisms Under the Biological Weapons Convention, UNIDIR, 2021, https://doi.org/10.37559/SECTEC/2021/SandTreviews/01.

- **Updating confidence-building measures.** These should reflect the contemporary life science research landscape and make better use of Confidence Building Measures submitted in efforts to overcome the deep distrust between BWC States parties.

- **Strengthening engagement and interaction with other stakeholders.** Any effort to develop a functional compliance mechanism now will depend on engagement with a wide range of actors, including industry, academia, and civil society. As indicated above, such actors have played an important role in national measures designed to manage biological risks. States parties could benefit from taking stock of these initiatives and exploring lessons learned. A functional arrangement will also require building relations with other international organizations, including bodies such as the Food and Agricultural Organization of the United Nations (FAO), the World Organisation for Animal Health (OIE), the OPCW, WHO, the World Meteorological Organization (WMO), the World Trade Organization (WTO) and the World Customs Organization (WCO), all of which can bring data and insights that are necessary to build a better picture of compliance.[101]

Turning back to the future for biological weapons verification

Ideally, each of the approaches described under the three section sub-headings above would form part of a balanced package of measures – one that addresses the diverse interests of all States parties enough to be regarded as a workable compromise. The contours of such a package are rather distinct from the 1990s vision of a comprehensive legally binding instrument containing a relatively intrusive verification regime. Yet many core components of the protocol discussions would be captured in three sections above. And, while less ambitious, our conclusion is that such an approach draws from insights from the past but better fits current political and technological realities.

It is now more than two decades since the failure of the Ad Hoc Group negotiations, and almost three since the findings of the VEREX report were adopted. For much of the period since 2001 in the BWC process, measures to enhance confidence in compliance with the Convention's prohibitions tended to be seen through the lens of the draft protocol. To date this has failed to strengthen the Convention. We conclude with the suggestion that it is now time for both sceptics and supporters of the draft protocol to acknowledge the overall landscape, as well as the terms of the debate, have changed – quite radically in some ways. In the 2020s, it is time to look at measures to enhance confidence in compliance with the Convention with fresh eyes, and on their own merits.

[101] According to Taylor, "The World Customs Organization, the Financial Action Task Force (and its regional affiliates) and the International Criminal Police Organization have important expertise in legal and illegal exports, imports, technology transfers, and related financial transactions." T. Taylor, "Lessons to Be Drawn from the Search for Iraqi WMD", Bulletin of the Atomic Scientists, vol. 77, no. 4, 2021, pp. 180–183, https://doi.org/10.1080/00963402.2021.1941553.

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