Technological convergence: What impact for the Chemical and Biological Weapons Conventions?

(*Inserm, Paris, 20 February 2013*)

The signing of the Chemical Weapons Convention (CWC) constituted a crucial step in the fight against chemical weapons. It remains the major international instrument providing for the eradication of a category of weapons of mass destruction and associated with a strict verification regime. This seminar took place in the context of the run up to the Third Review Conference of the Chemical Weapons Convention, which remains a cornerstone of the multilateral and non-proliferation regime. The Foundation for Strategic Research thus intends to contribute to the discussions regarding the evolution of the non-proliferation regimes against chemical and biological weapons and the strengthening of existing multilateral instruments.

In 2008, in the context of the Second Review Conference, the Foundation also contributed to this debate, through a seminar on "***The new challenges of chemical proliferation: What could be their impact on the Chemical Weapons Convention and on the Organization for the Prohibition of Chemical Weapons?***", organized on behalf of the Delegation for Strategic Affairs of the French Ministry of Defence. "*How can the chemical weapons prohibition system take account of scientific and technological developments?*" happened to be one of the key questions addressed during the seminar. The participants agreed that one of the challenges comprised the question of how to take into account the convergence between chemistry and biology.

Focusing on scientific and technological convergence, this seminar can be considered as a follow-up. To promote an open debate, the meeting was held under the Chatham House Rule. Bringing together people from various backgrounds, including scientists and experts of arms control and non-proliferation, both from the private and the public sectors, it also represented an outreach opportunity to involve a broader community in the debate and to contribute to raising awareness.

This seminar would not have been possible without the contribution of a number of colleagues and experts. We would like to thank them for their time and expertise:

Patrice BINDER, *National Institute of Health and Medical Research (France)*

Jean-François DAGUZAN, *Fondation pour la Recherche Stratégique (France)*

Malcolm DANDO, *University of Bradford (United Kingdom)*

Alexei GRINBAUM, *LARSIM Laboratory, CEA-Saclay (France)*

François LE FEVRE, *Genomics Institute, CEA (France)*

James REVILL, *SPRU – Science and Technology Policy Research (United Kingdom)*

Roger ROFFEY, *Swedish Defense Research Agency (Sweden)*

Françoise ROURE, *High Council for Economy, Industry, Energy and Technologies, France*

Katie SMALLWOOD, *World Health Organization*

Ralf TRAPP, *International Disarmament Consultant*

Jim WHITMAN, *University of Bradford (United Kingdom)*

Edward H. YOU, *Federal Bureau of Investigation (United States)*

The FRS would like to take this opportunity to thank all other participants who kindly agreed to take part in the seminar. Their insightful comments helped to make this event a success. The FRS would also like to extend its special thanks to the National Institute of Health and Medical Research (Inserm) for hosting this seminar.

The report reflects the rapporteur's personal interpretation of the proceedings and as such does not reflect any official position or the views of the rapporteur or of the Fondation pour la Recherche Stratégique.

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8:45 – 9:00	*Welcome*
9:00 – 9:15	**Introduction**
9:15 – 10:45	**Science and Technology Convergence: Mechanisms and Applications**
	Moderator: *Jean-François Daguzan, Fondation pour la Recherche Stratégique*
	Converging Technologies : A European Perspective *(Françoise Roure, High Council for Economy, Industry, Energy and Technologies*)
	Governance Challenges of Science and Technology Convergence (*Jim Whitman, University of Bradford*)
10:45 – 11:00	*Coffee Break*
11:00 – 12:30	**Risks and Threats Pertaining to Converging Technologies**
	Moderator: *Patrice Binder*, *National Institute of Health and Medical Research*
	Nanotechnologies (*Alexei Grinbaum, LARSIM Laboratory, CEA-Saclay)*
	Neurosciences (*Malcolm Dando, University of Bradford*)
	Systems and Synthetic Biology (*François Le Fèvre, Genomics Institute, CEA*)
12:30 – 14:00	*Lunch Break*
14:00 – 15:30	**Impact of Science and Technology Convergence on the Non-Proliferation Regimes against Chemical and Biological Weapons**
	Moderator: Nicolas Coussière, *Delegation for Strategic Affairs*
	Implication of Science and Technology Convergence on the Operation of the Chemical Weapons Convention (*Ralf Trapp, International Disarmament Consultant*)
	Convergence of the Life Sciences, Engineering and Physical Sciences and Impact on the Biological and Toxins Weapons Convention (*Roger Roffey, Swedish Defense Research Agency*)
15:30 – 15:45	*Coffee break*
15:45 – 17:15	**Governance and role of scientists**
	Moderator: *Patrice Binder*, *National Institute of Health and Medical Research*
	Taking into Account the impact of Science and Technology Convergence: Role of Experts and Scientists (*Katie Smallwood, World Health Organization*)
	Awareness Raising and Education about Challenges and Threats resulting from Science and Technology Convergence (*James Revill, Harvard Sussex Program*)
	FBI and American Association for Advancement of Science joint process on dialogue between Universities and Federal Bureau of Investigation (*Edward You, Federal Bureau of Investigation)*
17:15	**Concluding remarks**

Science and Technology Convergence: Mechanisms, Applications and Challenges

'Technological convergence' describes of broad trends in science and technology. This term, which has been widely used in the field of information and communication technologies, now includes other meanings, such as the convergence of chemistry and biology at the nanoscale, and the added value and outputs from multidisciplinary teams. It applies to politically supported, dedicated efforts in the United States and within the European Union to create a 'single engineering paradigm,' combining nanotechnology, biotechnology, information technology, robotics and cognitive science. Scientific laboratories relying on a multidisciplinary approach develop tools for the future. An inherent feature of scientific research is that it can lead to both beneficial applications and misuse, and the dual-use dilemma is relevant for technological convergence. This calls for efforts to foresee potential future challenges without neglecting a focus on current challenges.

The US and the EU have developed two different approaches with technology "for" versus "of" the mind. This philosophical debate has an impact on the way scientific roadmaps have been drafted. Published in 2004, the CTeks Report can be deemed as a European answer to the National Science Foundation (NSF) report about "NBIC Convergence for Human Enhancement". Technological Convergence has since been approached through scientific roadmaps and societal aspects, with bridges in between, as the Technology Readiness Levels stayed low in applications.

The EU report '*Converging Technologies – Shaping the Future of European Societies*'[1], published in 2004, states that 'Each [of the likely characteristics of [converging technologies applications] presents an opportunity to solve societal problems, to benefit individuals, and to generate wealth. Each of these also poses threats to culture and tradition, to human integrity and autonomy, perhaps to political and economic stability.' Recognizing these challenges, the Human Brain Project[2], selected under the FET (Future and Emerging Technologies) Programme launched by the European Commission, includes for example an ongoing assessment of its potential impacts, aiming at exploring the ethical, social and philosophical implications resulting from its multidisciplinary approach.

More broadly, seeking to promote responsible research at European level, the Directorate-General for Research and Innovation published in February 2013 a new report on *Options for Strengthening Responsible Research and Innovation (RRI)*[3]. Underlining the need for a comprehensive and common approach to develop processes and standards for RRI as well as for a better integration of ethical concerns, the report identifies examples of contested innovations, some of them resulting from convergence, including biotechnology, genetically modified organisms nanotechnologies, stem cell research or dual use robotics. The challenge involves managing the transition from a political to an educational level.

The evolution of scientific and technological capacities does not mean that they will be misused, as other parameters will have to come into play, such as the malevolent intention to misuse these capacities. However, integration of recent scientific and technological advances already place social, ethical and legal systems of deliberation under considerable strain and the impact of their potentially 'transformative" effects on human relatedness cannot be accurately anticipated. The pace of innovation is faster than the development of relevant regulations and governance mechanisms. Some committees are for example still exploring the consequences of first and second generations of nanotechnologies as the fourth one already exists.

[1] http://ec.europa.eu/research/social-sciences/pdf/ntw-report-alfred-nordmann_en.pdf
[2] www.humanbrainproject.eu
[3] http://ec.europa.eu/research/science-society/document_library/pdf_06/options-for-strengthening_en.pdf

Looking at developments in nanotechnologies, synthetic biology or neurosciences highlight some of the security, health, ethical and social challenges resulting from scientific and technological convergence and that will have to be addressed, including in the arms control field.

At the nanoscale, physicochemical properties of materials differ from those displayed by macromaterials. The lack of joint methods for describing nano-objects leads to discrepancies between threats and perceptions. Following an interdisciplinary workshop in Paris, in 2012, the Committee on Data for Science and Technology (CODATA) of the International Council for Science (ICSU) agreed to join forces with the Versailles Project on Advanced Materials and Standards (VAMAS) in order to develop a pre-normative project, with the drafting of a White paper defining the requirements for a description system for materials at the nanoscale. Elaborating on this paper, the next objective is then to develop a project open to international collaboration.

Besides, nanomaterials toxicology is still an emerging field. Assessment of the toxicity of nanomaterials encounters challenges as their unique properties can interfere with the use of classical toxicity assays, requiring the development of specific established methods. The lack of standardized methodology and guidelines can indeed hinder comparison of safety/toxicity assessments obtained by different research teams. Characterization of nanoparticules (size, shape, solubility to name only physical properties) is an important prerequisite in order to be able to establish a correlation between properties and biological effect. However, nanotechnologies also provide a large array of means of detecting threats before they become threats.

Synthetic biology, an emerging field characterized by a strong multidisciplinary approach with blurred boundaries, has also been identified as a Dual Use Research (DUR). On the one hand, there are many beneficial applications, mainly in the health, food, environment, energy and materials sectors, on the other hand, potential for misuse does exist. The time and costs of gene synthesis have decreased, allowing researchers to design and purchase multiple variants of the same sequence, in order to identify genes or proteins with optimized performance. Perils of synthetic biology can encompass impacts on human health and on environment, bio-errors as well as terrorism. In this context, the synthetic biology community has recognized the importance of standards and standardization. Moreover, the evaluation of the consequences of the advances in biotechnology and nanotechnologies requires that a development of a joint evaluation methodology, if this is achievable.

Considering neurosciences, the identification of novel chemicals with the potential to affect brain or other human bodily functions raises certain questions. Social engineering is at stake in this field. Definition of acceptable risks may vary. The debate tends to focus on the safety-margin and the possibility to assess if non-lethality is achievable. However the key question should be about the consequences on the Conventions if such requirements of non-lethality were met.

Combined with institutional interests, competitive impulses and realistic fears, some rationales and rationalizations explain at least an implicit acceptance of the risks: a benefits/risks assessment favouring benefits, interests trumping fears, the case for precaution being no stronger than the case for advancement as both benefits and risks are not accurately calculable, a belief that risks/threats can be dealt with on a case-by-case basis, and a belief that the benefits will provide an edge against threats.

One may wonder whether these evolutions are comprehensively covered by the existing non-proliferation instruments, including the CWC and the BTWC. Addressing adequately and more efficiently the resulting challenges, including in the framework of the Conventions, raises the question of an improved involvement of industrial stakeholders, professional associations, national academies, and other scientific and academic actors in governance issues. Considering arms control, it is also important to identify what it can achieve and what is not relevant. It cannot deal with societal issues. For example, linking security and safety is not easy in the chemical field, but it could be useful to evaluate how environmental issues have been taken into account.

Governance and the role of scientists

Soft regulation may offer one means of proceeding at the current time because of the uncertainty characterizing scientific and technological convergence. Devising ways to raise awareness about dual use and engaging scientists remains a key challenge. There is a need to develop national guidelines and to evaluate the possibility of launching an initiative in order to devise a global policy and a clearance mechanism for facilities and personnel involved in dual use biological and chemical research of concern. A greater role for national authorities in funding and promoting raising awareness and education should be considered. Besides, experience sharing and joint technical reviews on education could be organized between the CWC and the BTWC communities.

Experiments on the H5N1 avian flu virus triggered an important debate within the scientific community about the rationality of conducting such research and the dissemination of results including through publications and seminars. Balancing scientific openness and national security remains challenging. Compared with biosafety issues, the awareness about the risks of misuse of the life sciences remains limited. There is no coordinated top-down approach and existing curricula or training at university level or in research laboratories tend to focus on biosafety issues while biosecurity issues are far less developed or even left out of the picture. Education of scientists is thus a key aspect, all the more so that it is difficult to ask them to provide dual use assessments if they have not received proper information. Moreover, the issue of perception is important nowadays, and needs to be addressed through educational programmes at school and at university levels. Data is just one part of the message, and it is crucial to think about the power of words and images.

Codes of conduct can prove valuable in this respect but they are not sufficient in themselves. Some may be formulated more like political instruments, laboratory staff then not knowing how they relate to their day-to-day work. As an example, an EU Code of conduct for responsible nanosciences and nanotechnologies research was adopted in 2008. Scientists were not involved in the drafting process. This led a number of stakeholders to react to the “accountability” principle which states that researchers and research organizations should remain accountable for the social, environmental and human health impact that their Nanosciences and Nanotechnologies research may impose on present and future generations. It highlights the relevance of the involvement of scientists in the process.

Recognizing these biosecurity challenges, including those generated by synthetic biology and the emergence of biohacking, the US Federal Bureau of Investigation (FBI) aims to build bridges between the science and security communities, through outreach activities, partnerships and policy making. For example, since 2009 the FBI has sponsored the International Genetically Engineering Machine Competition (iGEM), first undergraduate Synthetic Biology competition. These initiatives facilitate communication between both communities, and enable the development and dissemination of recommendations for building a collaborative framework. Exchanges work both ways, the FBI providing education while the scientific community provides feedback. The best way is to support practitioners through a cooperative, mutually beneficial approach and provide a space to report suspicious activities.

Among chemists and neuroscientists, lack of awareness about the dual use challenge also seems to be a major problem. Neuroscientists are largely ignorant of historical examples and of the potential for misuse associated with their research. To move forward requires efforts from professional bodies and an integration of these issues in the training of neuroscientists, which should be compulsory. For professionals, it may imply an organizational adaptation, based on risk assessment, to take security issues into account. It is important to acknowledge that stakeholders may have other priorities. Adopting a holistic approach, with dual use issue being one component of a broader question, may be more efficient. Moreover, it is possible to develop incentives in order to make security training valuable for employers. However, it may prove difficult to assess time, efforts and resources which will have to be devoted in order to remedy the current deficiency.

On another level, the assessment of the impact for the Conventions of scientific and technological advances and convergence would benefit from a greater involvement of scientific, academic and industrial stakeholders. In the context of the CWC, policy advisors are already involved in various fora, such as the OPCW Technical Secretariat, meetings of experts, the Scientific Advisory Board, the Implementation assistance programme (IAP), the International Union of Pure and Applied Chemistry (IUPAC) or delegations. This calls, however, for a closer look at the respective role(s) of technical experts and scientists, but also at who should be considered as such – or not –. The question of whether convergence in science should lead to convergence of the regimes is for example not one for scientists to answer. The question of independence will always be there, especially when policy and transparency issues are at stake. One should also mention activism and the role of non-governmental organizations such as the Federation of American Scientists or Pugwash conferences on Science and World Affairs, convened and led by scientists. Not undermined by subjectivity as they do not claim to be objective, they seek to exploit international scientific culture to drive political discourse.

Debate on the role of science in policy is not new but it should perhaps be more thoroughly explored. Besides, boundaries between science and policy are not respected and maintaining the perception of independence proves almost impossible. The only way in which science could maintain its autonomy and authority would be by remaining outside the policy domain altogether. From this perspective, motivating them to give expertise would however be difficult. A bottom-up initiative can only go so far without being complemented by a political approach.

Impact of Science and Technology Convergence on the Non-Proliferation Regimes against Chemical and Biological Weapons

From an arms control perspective, convergence can be viewed as an overlap of certain technical concepts that underlie the CWC and the BTWC. It blurs the boundaries between chemical and biological agents but also affects the scientific and technological knowledge base underlying the CBW, as well as production processes, R&D and industrial practices and controls. The convergence of chemistry and biology thus has a potential impact for both Conventions, and some toxins and bioregulators fall under the scope of both. But, to go further, one can wonder how synthetic biological systems that replicate and may cause diseases should be considered. All these developments may pose new challenges but also offer opportunities to support the operation of the Conventions.

The Biological and Toxins Weapons Convention (BTWC) mentions the issue of convergence. The scientific and technological developments identified as potentially relevant for the Convention include gene synthesis, biotechnologies, nanotechnologies, bioinformatics and computational biology. Past Review Conferences have reaffirmed the scope of the BTWC article I, which covers new threats resulting from advances in the life sciences and any new biological agents, be they natural or synthetic. Each article of the Convention may nevertheless be affected by advances in the life sciences. More specifically, the trends characterizing the scientific and technological landscape, including convergence and the increasing pace of knowledge diffusion, could for example hinder efforts of State Parties to meet their commitments under Article III of the Convention.

The BTWC includes a periodical review mechanism of new R&D developments based on national papers. Most of these reviews underline general trends in the life sciences, but they should focus more on specific issues that are most relevant to the Convention. Caution should prevail when describing progress which could potentially be misused by proliferators or non-state actors. State Parties or a UN expert group could prepare a periodical detailed report on how these developments can support the implementation of the Conventions. Considering the BTWC, they could contribute to investigations but also to the promotion of biosafety and biosecurity as well as to the improvement of disease detection and the public health response.

EU Council Position 2011/429/CFSP of 18 July 2011 relating to the position of the European Union for the Seventh Review Conference of the States Parties to the Convention stated three priorities: (a) building confidence in compliance with the BTWC, (b) supporting its national implementation, and (c) promoting its universality. From this perspective, considering the issue of convergence, a peer review mechanism appears to be a promising possibility. However, it still implies the formulation and agreement of a joint process. Developing joint assessment methodologies is also an achievable goal.

Focusing on the CWC, on the one hand, convergence may have an impact on the scope of prohibitions and for national implementation. Within the limits of the existing Schedules, it has consequences for verification of compliance, as it can affect the type of industries and the number of facilities which should be subject to declaration. For example, the question of considering biological and bio-mediated processes under the CWC would be raised. On the other hand, convergence can help to strengthen national preparedness and response capabilities, contributing to chemical warfare deterrence. It can also provide opportunities in terms of international cooperation, provided that the dual use issue is still taken into account.

One should carefully phrase a question submitted to a scientific body such as the SAB, otherwise this body will give only a scientific answer. Someone should also be tasked with scientific and technological issues in the Technical Secretariat, to examine at narrow specific issues.

Addressing these developments calls for an incremental process. It should rely on a combination of monitoring trends and evolutions, analyzing potential impacts and studying requirements for the adaptation of CWC implementation processes. Even if this is not necessary for decision-making at this stage, the following areas should be more thoroughly studied: industry verification, national implementation and the application of the General Purpose Criterion in practice, and adaptation of ICA (International Cooperation and Assistance) models to the changing international collaboration landscape. Besides, there should be greater interaction between both the CWC and the BTWC communities.

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