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THEMENSCHWERPUNKT

Natural Science and Technical Peace Research: Definition, History, and Current Work

Christian Reuter, Jürgen Altmann, Malte Göttsche, Mirko Himmel

Abstract: Scientific discoveries and technological innovations have always exerted a great influence on peace and security. New civil and military technologies are revolutionizing warfare. Particularly striking areas are cyber warfare and the rapid development of uninhabited weapon systems. Issues of nuclear disarmament, missile defence or space armament as well as chemical and biological weapons remain urgent. The conference SCIENCE · PEACE · SECURITY '19 aimed for an accurate understanding and fruitful discussions of today's and tomorrow's peace and security challenges. This includes natural science/technical as well as interdisciplinary contributions, focusing on problems of international security and peace-building as well as contributions dedicated to transparency, trust-building, arms control, disarmament, and conflict management. This special issue presents selected contributions based on discussions at the conference.

Keywords: Natural Science/Technical Peace Research, Computer Science, Peace and Conflict Studies

Schlagwörter: Naturwissenschaften/Technische Friedensforschung, Informatik, Friedens- und Konfliktforschung

1. Introduction

In July 2019, the Science Council, the most important scientific-political advisory panel in Germany, published its recommendations on the further development of peace and conflict research. They point to an urgent need for action to strengthen natural science/technical peace and conflict research, which in Germany is now structurally too precarious to meet

the massive need for policy advice.¹ Scientific discoveries and technological innovations have always exerted a great influence on peace and security.² New civil and military technologies are

1 Wissenschaftsrat, 'Empfehlungen zur Weiterentwicklung der Friedens- und Konfliktforschung (Drs. 7827-19)', 2019, 1–178.

2 Jürgen Altmann, Ute Bernhardt, and others, *Naturwissenschaft – Rüstung – Frieden*, Wiesbaden: Springer VS, 2017.

revolutionizing warfare.³ To address these challenges to peace and security by academic research requires an interdisciplinary approach. For example, issues of cyber-attacks or cyber-weapons must be addressed by computer science and political science, among others.

The ending of the Intermediate-Range Nuclear Forces Treaty, the use of chemical weapons in Syria, discussions about autonomous weapons systems or cyber threats are shaping current world political events. Especially in these days, in which nuclear, biological and chemical disarmament and arms control are facing major challenges and new technologies entail changes in social-political environments, natural science and technical peace research is gaining in importance. On the basis of existing findings from various natural sciences and technical disciplines (e.g. physics, chemistry, biology, computer science), natural science/technical peace research deals with the role of scientific and technical possibilities in the context of war, peace, armament and disarmament.⁴

Inspired by different approaches toward the above-mentioned topics, this compilation of different articles, which is based on the conference SCIENCE · PEACE · SECURITY '19 in Darmstadt⁵, gives good insights into current research. Furthermore, this special issue on natural science/technical peace research wants to enhance the understanding of current peace and security challenges. Therefore, it includes natural science, technical as well as interdisciplinary contributions from different fields of research, focusing on international security and peace.

2. Definition and History of Natural Science/ Technical Peace Research

Within the interdisciplinary field of peace and conflict research, technology, based on findings from various natural sciences and technical disciplines (e.g. physics, chemistry, biology, computer science), plays a key role in various forms of conflict resolution⁶.

Peace and conflict studies researches peace and war on the basis of scientific methods and theories from several relevant disciplines, as war and conflicts have almost always been present in humankind.⁷

Natural science/technical peace research is a broad field of research that deals with the role of natural scientific and technical possibilities in the context of war and peace, armament and disarmament.

The latter came into being with the development and proliferation of nuclear weapons in the East-West conflict since the 1940s.⁸ With the possibility of using nuclear weapons in war, scientific and technological innovations became strategically and politically relevant. Despite many public concerns, deterrence became the means of first choice. The best-known example of existing doubts from science is the „Russell-Einstein Manifesto“ from 1955, which calls for nuclear disarmament and a rejection of war in general. As a result, the Pugwash Conferences on Science and World Affairs were established. At the first conference in 1957 in Pugwash, Canada, 22 scientists from ten countries and from both sides of the Iron Curtain discussed strategies for nuclear disarmament. Ever since, the so-called „Pugwash Movement“ has been organizing workshops and conferences and conducting research concerning problems of nuclear weapons. A similar development occurred in West Germany with the „Göttingen Declaration“ of 1957, when leading physicists and chemists rejected the German government's demand for nuclear armament for the newly founded German military, the *Bundeswehr*. The Pugwash activities formed an important basis that enabled and supported subsequent international treaties on arms control. Based on such initiatives, scientific research groups were founded at renowned US universities in the 1960s. During the East-West conflict they investigated nuclear disarmament, arms control, non-proliferation and international security. In Germany, Carl Friedrich von Weizsäcker (by that time at the University of Hamburg) established a research centre on global issues. He can thus be considered as the founding father of the country's scientific and technical peace research.

In the 1980s, the first small German working groups were founded in Bochum, Darmstadt, Hamburg and Kiel. Since then, internationally renowned competencies have been built up. Within those groups, young researchers started to work in natural science/technical peace research and performed research on security policy implications of technologies. Furthermore, they became familiarized with associated interdisciplinary research methods. Highlights of this long-term development were the founding of the Research Association for Science, Disarmament and International Security (FONAS) in 1996, and the establishment of the first endowed professorship in the field of scientific peace research in 2006 at the Carl Friedrich von Weizsäcker-Centre for Science and Peace Research (ZNF) at the University of Hamburg. In 2010, the endowed professorship for Science and Technology for Peace and Security in the Department of Biology at the Technical University of Darmstadt was filled, but only for a few months. Seven years later, in 2017, a corresponding professorship was filled in the Department of Computer Science at the same university. Nowadays, only these two locations have university professorships in natural science/technical peace research. Furthermore, there is a junior professorship at the Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen as well as other positions in peace research institutes, most of which with a political science focus. Nevertheless, research in this area is very much needed.⁹

3 Christian Reuter, *Information Technology for Peace and Security – IT-Applications and Infrastructures in Conflicts, Crises, War, and Peace*, Wiesbaden, Germany: Springer Vieweg, 2019.

4 Christian Reuter and others, 'Zur Naturwissenschaftlich-Technischen Friedens- und Konfliktforschung – Aktuelle Herausforderungen und Bewertung der Empfehlungen des Wissenschaftsrats', *Zeitschrift für Friedens- und Konfliktforschung (ZefKo)*, 2020.

5 Christian Reuter and others, *SCIENCE PEACE SECURITY '19 – Proceedings of the Interdisciplinary Conference on Technical Peace and Security Research* (Darmstadt, Germany: TUprints, 2019) <<https://tuprints.ulb.tu-darmstadt.de/id/eprint/9164>>.

6 Altmann, Bernhardt, and others; FONAS, 'Forschungsmemorandum – Naturwissenschaftliche Friedensforschung in Deutschland', *Wissenschaft & Frieden*, 2016, 31–33 <<http://www.wissenschaft-und-frieden.de/seite.php?artikelID=2102>>; Neuneck G., 'Frieden und Naturwissenschaft', in *Handbuch Frieden*, ed. by Hans-J. Gießmann and Bernhard Rinke Wiesbaden: VS Verlag für Sozialwissenschaften, 2011.

7 Thorsten Bonacker, 'Forschung für oder Forschung über den Frieden? Zum Selbstverständnis der Friedens- und Konfliktforschung', in *Friedens- und Konfliktforschung*, ed. by Peter Schlotter and Simone Wisotzki, Baden-Baden: Nomos, 201, pp. 46–78.

8 Jürgen Altmann, Martin Kalinowski, and others, 'Naturwissenschaft, Krieg und Frieden', in *Friedens- und Konfliktforschung*, ed. by Peter Schlotter and Simone Wisotzki (Baden-Baden: Nomos, 2011), pp. 410–445.

9 Reuter and others, 'Zur Naturwissenschaftlich-Technischen Friedens- und Konfliktforschung – Aktuelle Herausforderungen und Bewertung der Empfehlungen des Wissenschaftsrats'.

These examples show that on the one hand, natural science/technical peace research includes disciplinary, theoretical and experimental research that is initially motivated by a political problem. On the other hand, science-based peace research also has to work on relevant scientific and technical questions over a long period of time which do not have an interdisciplinary character. An example of the Comprehensive Nuclear Test-Ban Treaty is geophysical research on whether or not one can tell from seismic signals if they come from an earthquake or an underground nuclear explosion.¹⁰ On the other hand, natural science/technical peace research addresses more actual issues and attempts to develop important statements for policymakers within a short time period. In such cases, interdisciplinarity, particularly the cooperation with social sciences, is fundamental. For example, one question here is whether missile defense in space could negate nuclear missiles so effectively that states could do without deterrence.¹¹ In summary, it can be stated that both types of research require a long-term continuity of scientific knowledge and methods.

In conclusion, natural science/technical peace research nowadays supports political processes of war prevention, disarmament and confidence building. Furthermore, this discipline analyses characteristics and consequences of new types of weapons and develops proposals for limitations as well as technical solutions.¹² Scientists who are aware of possible negative consequences of new technologies are researching, among other things, verification (i.e. checking of compliance with disarmament treaties), the restriction of innovations to peaceful goals, and the proliferation-resistant design of civil technologies with dual-use potential. This research serves to complement political science peace research.¹³

3. Current Work: Articles in this Special Issue

As already illustrated, natural science/technical peace research covers a broad methodological spectrum, ranging from disciplinary to interdisciplinary work. This special issue contains work from different research areas, varying in the degree of interdisciplinarity. We received many suggestions for articles. After two rounds of peer-review the following articles have been accepted:

The article *“A Developing Arms Race in Outer Space? De-constructing the Dynamics in the Field of Anti-Satellite Weapons”* was written by Daniel Lambach, lecturer for political science at the University of Duisburg-Essen, and Arne Sönnichsen, research assistant at the same university. The authors explain that existing fears of the militarization of space often lead to techno-determinist arguments. For example, the recent development of Anti-

Satellite (ASAT) capabilities among space powers like China and India is often described in terms of a technologically driven arms race. This article takes a Social Construction of Technology approach to deconstruct the dynamics of this supposed arms race. Using a case study of Mission Shakti, the 2019 test of an Indian ASAT system, it finds that while state officials made some security-related claims about their ASAT project, they placed a greater emphasis on status-seeking arguments. This offers possibilities for de-securitizing outer space.

In the article *“Towards IT Peace Research: Challenges on the Intersection of Peace and Conflict Research and Computer Science”* by Christian Reuter (Science and Technology for Peace and Security (PEASEC) at Technical University of Darmstadt) explains that advances in science and technology, including information technology (IT), play a crucial role in the context of peace and security. However, research on the intersection of peace and conflict research as well as computer science is not well established yet. This article highlights the need for further work for “IT peace research” which includes both empirical research on the role of IT in peace and security, as well as technical research to design technologies and applications for, amongst others, limitations and verification. Based on the elaboration of the disciplines, central challenges, such as regarding insecurity, actors, attribution and laws are outlined.

The article *“The state of cyber arms control. An International Vulnerabilities Equities Process as the way to go forward?”* by Matthias Schulze (German Institute for International and Security Affairs, SWP) analyses proposals for cyber arms control, modelled after traditional arms control regimes. Although the threat of cyber-conflict rises, not much ground has been gained with cyber arms control regimes. The author finds that challenges of the digital domain, issues of regime verification and the lack of political will are big inhibitors in transferring these to the cyber-domain. To overcome these inhibitors, cyber experts proposed a new type of regime focusing on zero-day vulnerabilities. Since nobody so far explained, what a so-called International Vulnerabilities Equities Process (IVEP) could look like, the article takes up the task and presents two original models. It then checks, whether or not these can overcome the identified inhibitors. The article concludes that at the current state, an IVEP is not feasible as a cyber-arms control alternative and that future research into the structural elements and interest constellations is needed.

The article *“Cyber Threat Intelligence Sharing between States”* by Philipp Kühn, Thea Riebe, Lynn Apelt, Max Jansen and Christian Reuter (Technical University of Darmstadt) investigates Cyber Threat Intelligence (CTI) platforms which are used in IT-security management to share and analyse cyber threats for a collective crisis management. The article discusses if CTI platforms can be used as a confidence-building measure between states and international organizations. Current CTI platforms are portrayed, deducting political requirements, and answers are offered to the question of how CTI communication may contribute to confidence-building in international affairs. The results suggest further development of analytical capabilities, as well as the implementation of a broad social, political, and legal environment for international CTI sharing.

10 P G Richards and J Zavales, ‘Seismic Discrimination of Nuclear Explosions’, *Annual Review of Earth and Planetary Sciences*, 18.1 (1990), 257–286.

11 David Hafemeister, ‘The Defense: ABM/SDI/BMD/NMD’, in *Physics of Societal Issues*, New York, NY: Springer 2014, pp. 55–76.

12 Jürgen Altmann, ‘Einführung’, in *Naturwissenschaft – Rüstung – Frieden. Basiswissen für die Friedensforschung*, ed. by Jürgen Altmann and others, Wiesbaden: Springer VS, 2017, pp. 1–7.

13 Reuter and others, ‘Zur Naturwissenschaftlich-Technischen Friedens- und Konfliktforschung – Aktuelle Herausforderungen und Bewertung der Empfehlungen des Wissenschaftsrats’.

The article “Towards a Prospective Assessment of the Power and Impact of Novel Invasive Environmental Biotechnologies” by Johannes L. Frieß and Bernd Giese (both University of Natural Resources and Life Sciences in Vienna) and Anna Rössing as well as Gunnar Jeremias (both Carl Friedrich von Weizsäcker-Centre for Science and Peace Research, Hamburg) investigates novel invasive environmental biotechnologies, namely gene drives and Horizontal Environmental Genetic Alteration Agents, which exceed the classical applications of genetically modified organisms. This article presents a first preliminary examination whether international regulation is prepared for possible conflicts caused by benevolent or hostile use of these technologies. Potentially relevant international treaties are identified, and open questions regarding export control are briefly addressed. The authors conclude that further investigation is called for and recommend scenario-building as a useful tool to explore potential consequences that may arise from application contexts of these novel technologies.

The article “New Military Technologies: Dangers for International Security and Peace” by Jürgen Altmann (Technical University of Dortmund) focuses on new military technologies that are being developed at a high pace, with the USA in the lead. Intended application areas are space weapons and ballistic missile defence, hypersonic missiles, autonomous weapon systems and cyber war. Generic technologies include artificial intelligence, additive manufacturing, synthetic biology and gene editing, and soldier enhancement. Problems for international security and peace – arms races and destabilisation – will likely result from properties shared by several technologies: wider availability, easier access, smaller systems; shorter times for attack, warning and decisions; and conventional-nuclear entanglement. Preventive arms control is urgently needed.

4. Summary

In sum, our special issue gives an overview of current research projects and challenges in natural science and technical peace research. The articles focus on (1) anti-satellite weapons, (2) challenges on the intersection of peace and conflict research and computer science, (3) cyber arms control, (4) cyber threat exchange, (5) novel environmental biotechnologies, and (6) increased threats of novel military technologies. We are very grateful to all authors and reviewers for their contributions as well as to the editorial team of the journal S+F (Security and Peace) who made this special issue possible.

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Prof. Dr. **Christian Reuter**, full professor for Science and Technology for Peace and Security (PEASEC), Technical University of Darmstadt. Focus: interactive and collaborative technologies in the context of crises, security, safety, and peace.



PD Dr. **Jürgen Altmann**, head of the research group on Physics and Disarmament at TU Dortmund. Focus: military-technology assessment of automated and autonomous weapon systems; questions related to natural science and technical peace research.



Prof. Dr. **Malte Göttsche**, assistant professor and head of the Nuclear Verification and Disarmament Group at RWTH Aachen. Focus: nuclear verification technologies, related simulation tools, radiation detection and non-proliferation and disarmament policy.



Dr. **Mirko Himmel**, scientist at the Carl Friedrich von Weizsäcker-Centre for Science and Peace Research, University of Hamburg. Focus: technologies for preventive biological and chemical arms control; infectious biology; bioethics.

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